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AMERICAN RAILWAY JOURNAL.

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THE NEW YORK RAPID TRANSIT BOND DECISION, handed down by the Appellate Division of the Supreme Court on the application of the Rapid Transit Commission, modified its previous decision as follows: Instead of a continuous bond of $15,000,000 to be given by the contractors for building and operating the road for fifty years, the court now decides that $14,000,000 of that bond shall be conditioned upon the construction and equipment of the underground railway, and that $1,000,000 should be a continuous security applicable to construction, equipment, rents, maintenance and operation. The Rapid Transit Commission suggested a deposit of $1,000,000 by the contractor, to be returned upon completion of construction and equipment; the withholding of a reasonable percentage of the price of construction, to be paid upon completion; a bond, not exceeding $7,500,000, to secure construction and equipment; a lien upon the equipment, and lastly a bond, which, with the cash value of the equipment, shall equal the estimated rental for seven years. President A. E. Orr, of the Rapid Transit Commission, says that this decision removes one of the greatest stumbling blocks in the carrying out of the underground project. A $15,000,000 bond for 50 years was prohibitory; and while the new bond is excessive, in his estimation, he thinks it can be raised.

THE CRISIS IN THE PHILADELPHIA WATER SUPPLY appears to be passed for the present, so far as the water contract ordinance noted in our last two issues is concerned. On coming up the second time in the common council the friends of the bill made no headway, and finally indefinite postponement was precipitated by a declaration from one of the councilmen, Mr. Walter N. Stevenson, that he had been offered a bribe of $5,000 to vote for the bill. This led to the appointment of an investigating committee, which began its public sessions on March 15. It is supposed that the bill will not come up again in the present councils, but that it will be revived, if possible, in the new councils, already elected and soon to be organized.

WATER WAS TURNED INTO THE NASHUA AQUEduct of the Metropolitan Water Supply System for Boston and vicinity on March 7. The water is taken from a temporary reservoir on the Nashua River and flows through the aqueduct to the Sudbury Reservoir, formerly known as Reservoir No. 5. From this reservoir the water will pass through the Sudbury Aqueduct, the Nashua supply supplementing that from the Cochituate and Sudbury sources. The Mystic supply, which was objectionable in quality, and which was furnished by Boston to a part of its territory, and to Somerville, Everett and Chelsea, has been shut off since about Jan. 1, when the board assumed control of that part of the Boston water-works outside the city distribution system. Besides Boston and the three places just mentioned, the board is now supplying water to Malden, Medford and Melrose, by pumping into Spot Pond, the old source of supply for these places; in addition, a partial supply is being furnished to Revere and Winthrop. It is expected that before the close of the present season Quincy, Watertown and Belmont will be supplied. These twelve cities and towns are all the municipalities yet actually included within the Metropolitan Water District, but the act forming the district provides for including 16 more. We are indebted to Mr. Dexter Brackett, M. Am. Soc. C. E., Engineer of Distribution, for the above information, which he gave to a representative of this journal at the office of the board. Mr. F. P. Stearns, M. Am. Soc. C. E., is chief engineer of the board.

THE NEW CROTON AQUEDUCT, for New York city, has cost, to Jan. 1, 1898, $36,529,115, according to the last report of the Aqueduct Commission. Among the expenditures itemized are the following: Maintaining Commissioner's office, $637,578; Chief Engineer's office, $740,190; Tarrytown office, $128,462; division engineers, $2,241,828; Croton Lake survey, $40,768; new reservoir survey, $10,118; Sodoun Dam survey, $7,305; Principal Engineer's office in New York, $432,872.

THE WATER POWER PROJECT in connection with the Chicago Drainage Canal, at Joliet, Ill., has been definitely abandoned by the trustees of the Sanitary District. The State Canal Commissioners opposed the establishment of the plant, and after lengthy negotiations the trustees, on March 11, voted to abandon the project and adopt another route through Joliet, on the ground that the opening of the canal and the purification of the water supply of Chicago is of greater importance than the water power plant. Only three of the trustees voted in favor of adhering to the original plans.

THE AUSKERADA WATER POWER PLANT, on the Auskerada river, at Dolgeville, N. Y., which was formally put in operation on Jan. 15, consists of a masonry dam at High Falls, and a steel flume leading to the power house where are located two 36-in. Victor horizontal turbines and two dynamos of 350 kilowatts, developing 3,600 HP. The dam is 20 ft. high, 250 ft. long, 7 ft. wide at the top and 20 ft. at the bottom. The flume is 10 ft. diameter and 500 ft. long, supported on masonry piers 16 ft. apart. The head at the wheels is 72 ft. The plant was designed by Mr. A. C. Rice, engineer of the Stilwell-Bierce & Smith-Vaile Co., of Dayton, O., and that company furnished the water-wheels, while the dynamos were built by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa. Mr. W. H. White was the Resident Engineer. The contractors for the dam and power house were McCaghey & Linehan, of Sandy Hill, N. Y. The plant is owned by the Dolgeville Electric Light & Power Co., of which Mr. E. R. Wanckel is President.

ELEVEN PERSONS WERE KILLED in New York city, on March 13, as the result of a fire in a mission hotel on the Bowery. The fire occurred at 1:40 a. m., at a time when fully 150 men were asleep in the building. It is believed that the fire was the result of some one carelessly throwing a lighted match or cigarette into a pile of waste paper.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Kanawha & Michigan division of the Ohio Central Lines, about 40 miles east of Charleston, W. Va., at a place called Gauley, on March 8. The cause of the accident is not known, and only one death is reported.

THE SNOQUALMIE FALLS POWER CO., of Seattle, Wash., has inaugurated the work of developing the water power of the Snoqualmie Falls, and transmitting the power electrically to Seattle and Tacoma, Wash., 23 and 35 miles respectively. The falls are 268 ft. high, and will give an available power of 100,000 HP., but the present plan is to develop about 8,000 HP. at the wheels. Mr. Thomas T. Johnston, of Chicago, is Chief Engineer, and is now completing the plans, organizing the work and shipping machinery for construction.

THE BUILDING OF A GREAT SHIPYARD on New York Bay or on the shores of the Hudson is suggested by Mr. Andrew Carnegie in a letter in the "Iron Trade Review" of March 3. He says that steel ship plates are now $7 to $8 per ton lower in New York than they are in Glasgow, and that in a couple of years they can be brought from Pittsburg to New York for $1 per ton. This assumes that they will be carried for nothing from Pittsburg to Conneaut in Lake Erie in Mr. Carnegie's cars that carry his ore from Conneaut to Pittsburg, and that the lake and canal freight will be reduced to $1 per ton after the Erie canal is deepened. Mr. Carnegie thinks that with the best modern appliances ships could be built at a lower labor cost than at any yard in Great Britain or in Germany.

THE CHICAGO SHIP BUILDING CO. launched, on March 5, the "William R. Linn," with a freight capacity of 5,800 tons. This ship is 420 ft. long over all, 400 ft. on the keel, 48 ft. beam and 28 ft. deep. She is equipped with quadruple expansion engines supplied by two powerful Scotch boilers. She can, in an emergency, carry a battery of eight 6-pdrs. and four rapid-fire guns, and steam at 15 miles per hour. Her machinery can be thoroughly protected and her decks would carry 1,000 men.

THE "LARGEST TANK-STEAMER IN THE world" will soon be launched for the Standard Oil Co. at the Roach Shipyard in Chester, Pa. The capacity will be 720,000 gallons of oil and the ship will cost $250,000. The dimensions are as follows: Length over all, 254 ft.; beam, 40 ft.; engines, 1,500 HP.; speed, 12 knots per hour. The ship was designed by Mr. John Haug, of Philadelphia, the Engineer for the Standard Oil Co. The tanks are arranged fore and aft, with the machinery and men's quarters amidships. A longitudinal bulkhead divides the tank space in half, and three watertight cross bulkheads, forward and aft, make twelve main tank divisions. To prevent the oil from reaching the fires by leakage, two wells are located, one on either side of the machinery space, and these are filled with water. Each well can be pumped out from the deck through a small tank capping each well. Extension tanks on deck, connected with the main tanks, take up any surplus oil shifted by the rolling of the ship, and keep the main tanks always full. Large vent hatches cap each of the deck tanks and provide a means for the escape of gas. Four filling mains connect with the deck tanks, and through these mains oil will be pumped into the tanks at the company's docks. Arrangements are also made for carrying and burning fuel oil, though this is as yet an experiment.

THE AMERICAN MAIL STEAMSHIP CO., lately incorporated for the British West Indian trade, is to at once build four new steamers of 2,000 tons each, at least 280 ft. long and 36 ft. beam. They will have engines capable of developing a speed of at least 15 knots, and will be designed to operate as auxiliary vessels to the U. S. Navy. The company has an authorized capital of $1,000,000, and the vessels will not be put onto any regular line or sail to any particular port, but be used for general tramp purposes. They will be faster and safer than the foreign vessels of this type now used in the American carrying trade to the West Indies and other points.

THE PORT ROYAL DRY-DOCK is reported as now accessible to battleships, the entrance channel having been sufficiently dredged for this purpose. The dredging contract calls for a depth of 30 ft. for a distance of 1,000 ft. from the entrance to the dock. There is now 20 to 22 ft. in this channel at this point, and a heavy vessel could be taken in on the high tide.

A LARGE DRY-DOCK is to be commenced at once by the Newport News Shipbuilding & Dry Dock Co., at Newport News, Va. This dock will be 900 ft. long and 90 ft. broad, and be capable of receiving two of the largest battle-ships at one time. The estimated cost is about $1,000,000, and the plans include no subsidy from the government. Plans are all completed and the work will be pushed to completion.

ENGLISH NAVAL ESTIMATES provide for the expenditure of $120,000,000 for new warships. Russia meets this by an imperial ukase setting aside 90,000,000 rubles, or about $70,000,000, for a similar purpose. With the $50,000,000 just appropriated by the United States Government, a total sum of $240,000,000 has been voted by three nations, within ten days, for the building or purchase of a navy.

THREE NEW BATTLESHIPS, at $6,000,000 each, are authorized in the report of the House Naval Committee. The building of dry-docks at Portsmouth, N. H., Boston, Mass., Algiers, La., Mare Island, Cal., and the enlargement of the League Island dry-dock at Philadelphia, was proposed. But this matter is complicated by the report of Commodore Matthews, Chief of the Bureau of Yards and Docks, concerning the depth of water in the channels leading to the sites of the intended docks. The least requisite depth is 30 ft., and the Mare Island channel has only 29 ft. for two miles, and the Boston and Philadelphia channels have only about 27 ft.

A NEW RAPID-FIRE GUN of 6 mm. caliber is being made at the Colt's Factory, at Hartford, Conn. This gun is fitted with a land and a sea mount; it is capable of firing 200 shots per minute and has a range of 6,000 ft. At a test made at the Brooklyn Navy Yard, a bullet was sent through a ⅜-in. steel plate, through 20 ins. of wood backing, through a steam-coil and finally through another ⅛-in. steel plate. The metal in the barrel is 1-in. thick, to prevent overheating, and the cartridges are fed from a belt, containing 1,000, stored in a steel box attached near the breech. This gun is now being turned out and forwarded to the navy yards in lots of 50 complete guns.

PROJECTILES FOR THE ARMY AND NAVY are in demand. The United States Projectile Co., of Brooklyn, is said to be busy on a $300,000 contract for armor-piercing projectiles. The Midvale Steel Works are at work on 2,000 steel projectiles, valued at $300,000, and the Carpenter Steel Co., of Reading, Pa., has just finished 5,000 shells for land fortifications, and is reported as having secured another contract for 11,000 ranging from 4-in. to 13-in. caliber.

AN OBJECT LESSON ON THE COST OF WATER BY METER MEASUREMENT.

All water-works officials who have attempted to introduce the meter system are more or less familiar with objections to "selling water by the pint" and similar utterances intended to inflame popular sentiment against putting any check on the use and waste of water. To enable the people of Philadelphia to see what large quantities of water they can have for a few cents, or even for one cent, Mr. John C. Trautwine, Jr., Assoc. Am. Soc. C. E., Chief of the Bureau of Water, has had constructed and photographed three cubes, the contents of which are, respectively, 1,000 cu. ft., 1,000 gallons and 2,000 pints. The prices of corresponding amounts of water are indicated in the photograph, as will be seen by the accompanying reproduction of it, while on the left there is a man holding a pint measure. The whole is entitled "Water By Meter at One Cent Per Ton."

We hope the illustration and the lesson it teaches will be taken to heart in Philadelphia, where the view has been published in the "Public Ledger," and possibly some other papers. We know it will be welcomed by water-works men in general as another aid in forcing home the truth that the water meter is not an instrument of extortion or niggardliness, but that it allows the use of large quantities of water at low prices, only requiring that each consumer shall pay for the water he uses and wastes.

Without meters the careful householder or manufacturer is compelled to pay for water wasted by the careless or negligent one. The waste does no one good, and costs money that in many places, and notably in Philadelphia, is needed to purify the water, so that it will give health to the user, instead of causing disease and hastening death. Many of the people of Philadelphia who object to the use of meters on the ground that the restriction of water consumption is prejudicial to health, forget that the water they are now using at the rate of 215 gallons a day is often unfit to put on the outside of the body, while to think of swallowing such water is nauseating. But when the water is the clearest it may be the deadliest, for clearness is no guarantee that it does not contain thousands of typhoid germs.

Cut the water consumption of Philadelphia in half, as might easily be done by the judicious use of meters, and the saving effected would go far towards purifying the water supply of the city.

THE SEWAGE FARM OF ACHERES, PARIS.

(With two-page plate.)

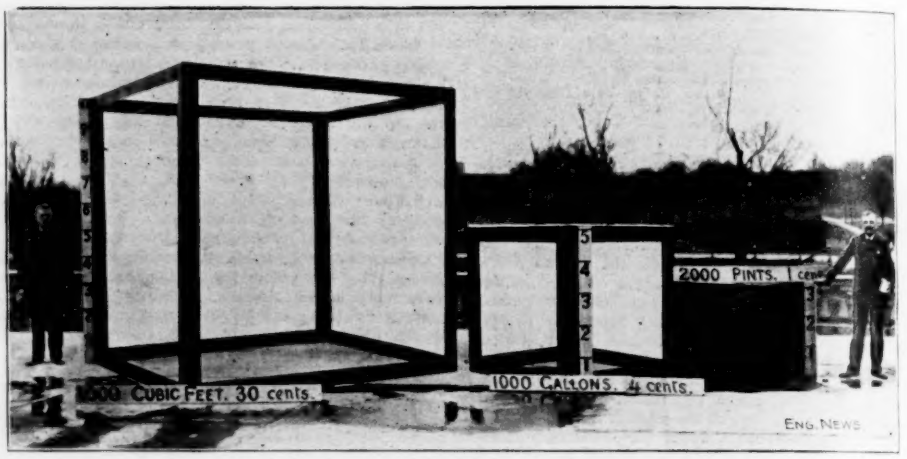
In our issue of Aug. 22, 1895, the new sewerage system and sewage farms of Paris were described and illustrated at considerable length. Since that date much of the work then in progress has been completed, and the results can now be studied. In the "Annales des Ponts et Chaussees," in the second quarterly edition for 1897, 266 octavo pages are devoted to a very detailed and fully-illustrated description of the aqueduct and sewage farm of Acheres, written by the engineers in charge, Messrs. Bechmann and Launay. The following article is prepared from the data contained in this exhaustive description:

The general scheme of the improved sewerage of Paris, adopted in 1889, included the construction of intercepting sewers along the banks of the Seine; the modification of existing sewers, so as better to convey house drainage; the centering of a large portion of the drainage at Clichy, and there lifting it by pumps and passing it under the Seine by a tunnel, and then by aqueduct and a bridge over the Seine to sewage farms at Acheres. This aqueduct of Acheres, as the part crossing the bend in the Seine is called, has a capacity of 344.4 cu. ft. per sec., or about 220,000,000 gallons per day, or a little more than twice the present sewage flow into the Clichy collector. The aqueduct is 9.3 miles long, from the lifting pumps at Clichy to the land to be irrigated, and the Seine is crossed a third time, at Herblay, by means of a siphon. Acheres is about 1,700 ft. beyond Herblay.

The article here quoted describes in detail the pumping plants at Clichy, and at Colombes, where sewage is provisionally taken to a sewage farm; the crossings of the Seine, by the Clichy and Herblay siphons, and by the steel aqueduct bridge of Argenteuil; the principal aqueduct, its conduits and galleries, and, finally, the sewage farm of Acheres.

The latter is the part of more immediate interest and our description will be mainly confined to the operation of this farm and the results secured to the present date. The land devoted to the purification of sewage, at Acheres, includes two farms, aggregating about 372 hectares in area, and about 427 hectares of the forest of Saint Germain; to this original area, under the law of 1889, about 200 hectares were added in 1894, and the total, 1,000 hectares, available, or about 2,470 acres, will permit the disposal of about 8,000,000 cu. m., or about 2,114,000,000 gallons per year. Another 2,470 acres alongside is available for further extension of the system.

From the last crossing of the Seine, at Herblay, the sewage enters the farm by two conduits, each 3.28 ft. in diameter; and from these conduits the distribution system branches in cement conduits, from 3.6 to 0.98 ft. interior diameter. The farm stretches along the Seine for about 6.2 miles in length, and with an average width of 0.62 miles. The principal conduits occupy the middle line of this band, and the secondary conduits are arranged practically at right angles to the mains. The entire surface is divided into four distinct zones of irrigation, each of which can be totally cut off from the general distribution by special gates and pressure-reducers. The land to be irrigated is cut into furrows and ridges, with the sewage flowing in the furrows in such manner that the roots of the plants are irrigated without wetting the leaves or covering the soil to be cultivated. The transverse, or secondary conduits, are spaced about 1,300 ft. apart, and the position of the openings in these conduits are fixed by the slope of the ground; these openings being approximately from 250 to 325 ft. apart.



WATER BY METER AT ONE CENT PER TON.—AN OBJECT LESSON.

The distribution conduits were made of a metallic skeleton covered with cement; for purposes of strength against a normal maximum pressure due to a head of 131.2 ft., and to protect the interior tube of steel from oxidation. These conduits were formed of sheet steel tubes, with soldered joints, running through the middle line of the conduits. As shown in Fig. 1, these tubes were strengthened, within and without, by bands and longitudinal bars of steel, of + section, imbedded in cement mortar. The metallic portion was thus entirely covered by the cement, as shown in the cut. An exception was made in the case of the conduits 0.98 ft. in diameter, which had a steel tube in the middle and a single set of steel bars on the outside. All conduits of 1.3 ft. diameter and over were about 10 ft. long, as made; and those of 0.98 ft. diameter, were only 6.82 ft. long.

In calculating the strength of these pipes the exterior armor was alone considered. This was disposed in two series of bars, one series running around the pipe, and the other lengthwise. The spacing of these bars was determined by the formula $\frac{S \times 2R}{HD}$; in which S was the section in square millimeters of the steel bar; R was the maximum tension, per square millimeter, to be imposed upon the steel; H was the interior water pressure, or head in meters, and D was the diameter of the conduit expressed in meters. The joint was made as shown in Fig. 1; this band being 0.65 ft. wide, and also containing two series of bars. Manholes, 1.96 ft. diameter, were provided for the larger conduits.

The manufacture of these pipes, which was conducted on the ground, was somewhat novel, and may be briefly described as follows: The sheet steel and the steel bars were delivered at the works cut to proper dimensions and lengths. The interior skeleton was first made by arranging the longitudinal bars in the notches of a mandrel provided, and securing them in position by two single iron wires. The other series of bars was then spirally rolled around the longitudinals in such manner as to preserve the spaces fixed upon, and each crossing of the longitudinals and spiral was tied by iron wire. Upon the skeleton thus made was slipped the sheet metal tube and the exterior series of bars was built up in a similar manner to the first; and in case the spiral was not long enough completely to encircle the tube, another bar was joined to the first by iron wire.

The manufacture of the steel tubes necessitated several special tools. Each tube was made up of three sheets united by a kind of hook-joint, which was flattened by a roll and then soldered. Three machines were required; one to cut the sheets; one to bend the metal for the joints, one to roll them into cylindrical form, and finally another to flatten, or roll the joints. To enable the ends of the cylinders to easily slip into each other, a fifth machine was used to slightly enlarge the diameter at one end. In the larger tubes, the circumference was made up of three sheets, also connected by hooked, rolled joints.

With the tube and the skeleton completed, these were taken to the cement mill; a mandrel was placed inside, corresponding to the interior diameter, and a mold outside, which equalled the exterior diameter. The sand and cement, used for the mortar, was mixed dry, and then water enough was added to make rather a stiff paste. This mortar was rapidly filled into the mold, and after an interval of from 15 to 30 minutes, according to the season, the forms could be removed. The pipe was then left in the air for two days, so that the cement might take a firm set, and it was later lifted by a broad collar placed at the center of gravity and conveyed on a truck to the storehouse. These conduits were so laid that the minimum depth of the trench, measured from the top of the pipe, would be one meter, or 3.28 ft. The furnishing of the materials and the manufacture of these conduits; the digging of the trenches and the refilling, cost as follows for each diameter of pipe:

Conduit. Inside diameter.	Per lin. meter. francs.	Per lin. ft.
1.10 m., or 3.61 ft.	.90	$5.49
1.00 m., " 3.28 "	.70	4.27
0.80 m., " 2.62 "	.42	2.56
0.40 m., " 1.31 "	.19	1.15
0.60 m., " 1.97 "	.33	2.01
0.30 m., " .98 "	.14	0.85

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	2.56
	1.15
	2.01
	0.85

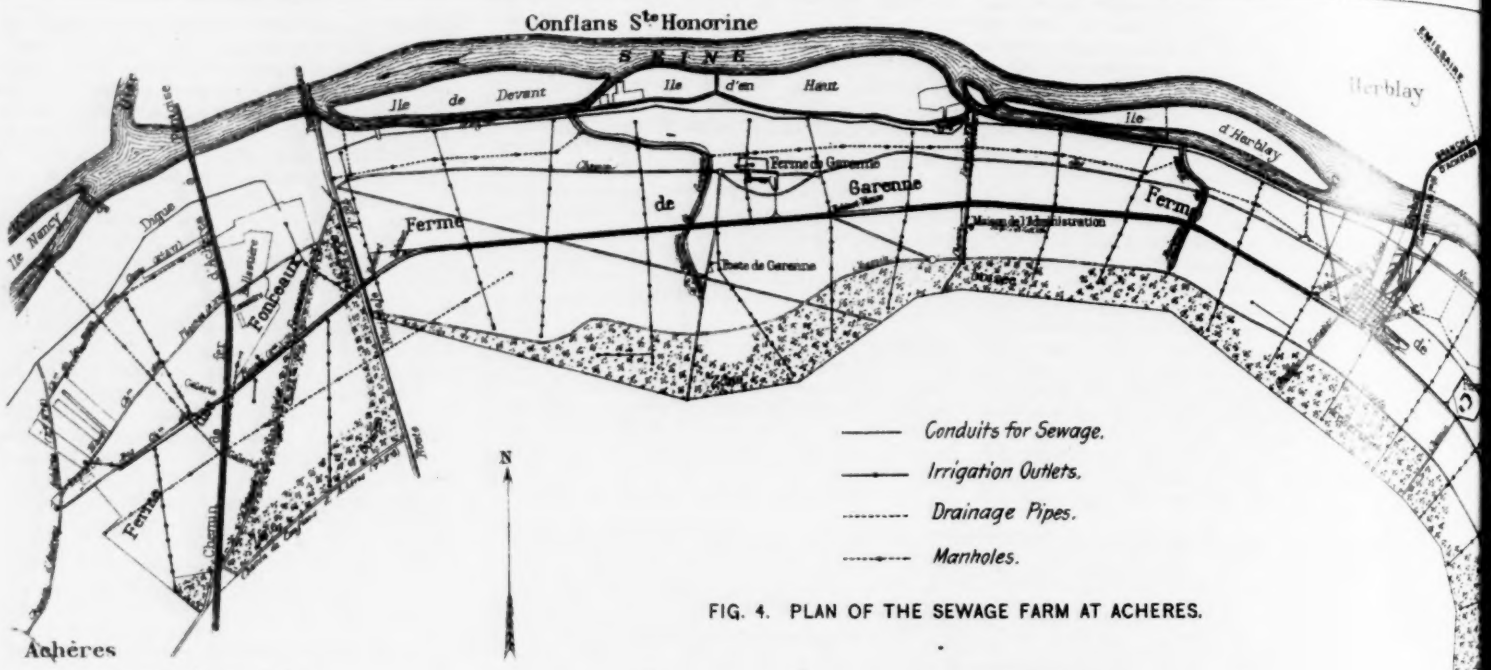
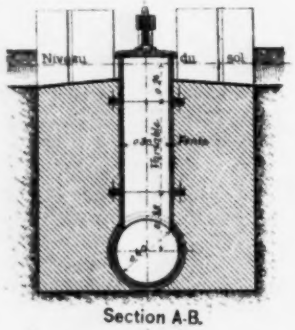


FIG. 4. PLAN OF THE SEWAGE FARM AT ACHERES.



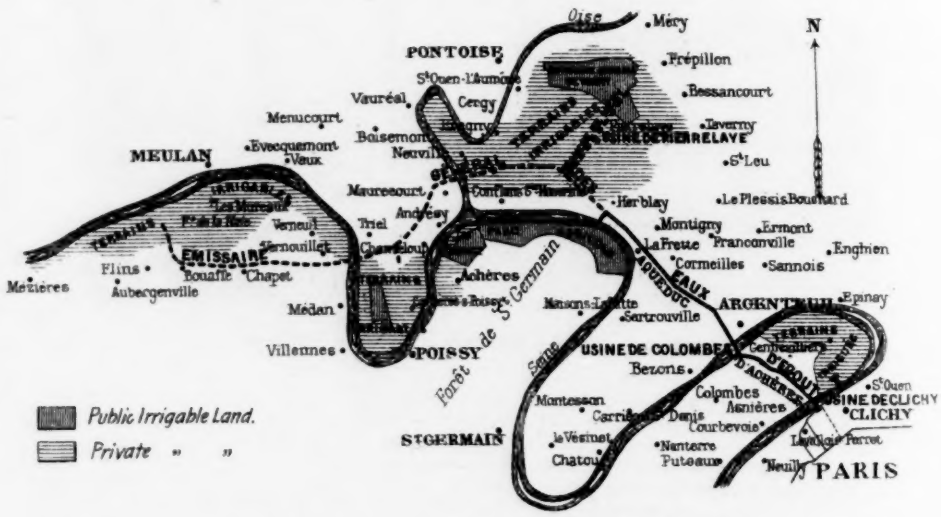


FIG. 5. GENERAL MAP OF THE IRRIGATION SCHEME.

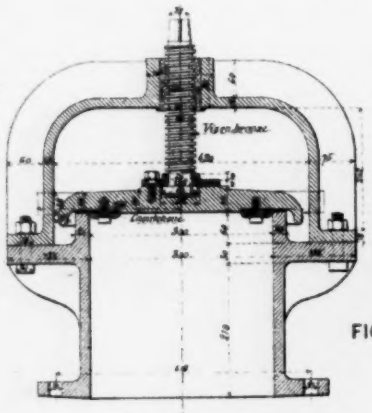


FIG.3. IRRIGATION OUTLET REGULATED BY SCREW.

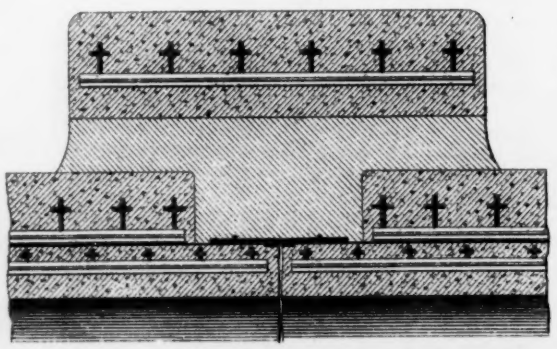


FIG. 1. JOINT FOR CONCRETE PIPE WITH METALLIC SKELETON.

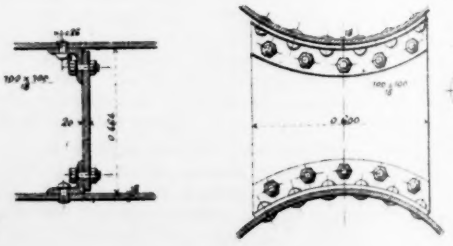


FIG. 9. PLATE-JOINT FOR ACHERES SIPHON.

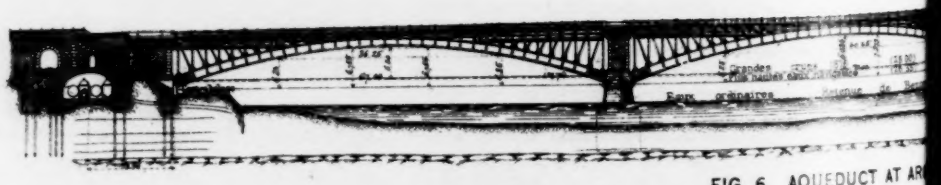


FIG. 6. AQUEDUCT AT AR[illegible]UIL.

THE TRUNK SEWER AND SEWAGE FARMS FO[illegible]HE

M. Huet, Director of Works.

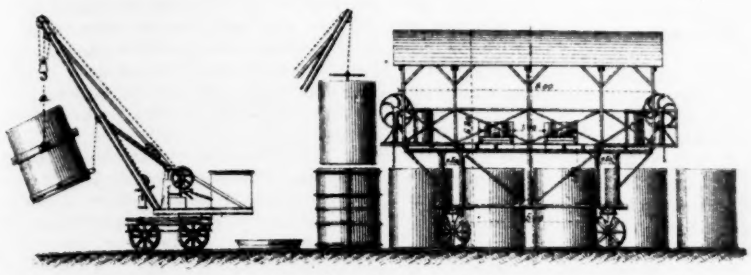


FIG. 12. PLANT FOR MOLDING THE ARMED-CEMENT PIPES.

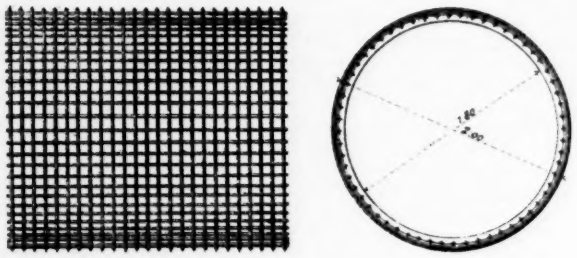
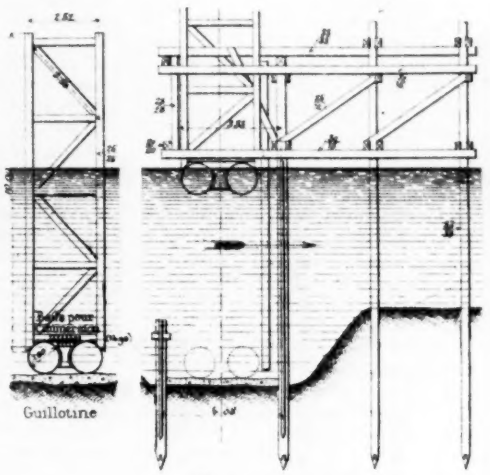


FIG. 13. SKELETON CONSTRUCTION DESIGNED FOR A HEAD OF 20 M.



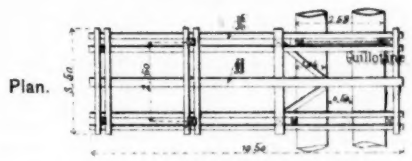


FIG. 10. PLANT FOR SINKING THE ACHERES SIPHON.

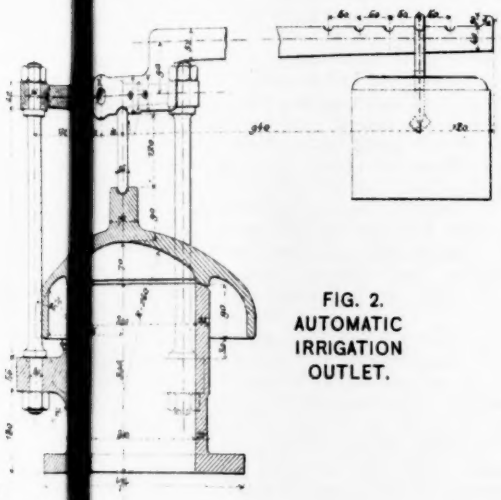


FIG. 2. AUTOMATIC IRRIGATION OUTLET.

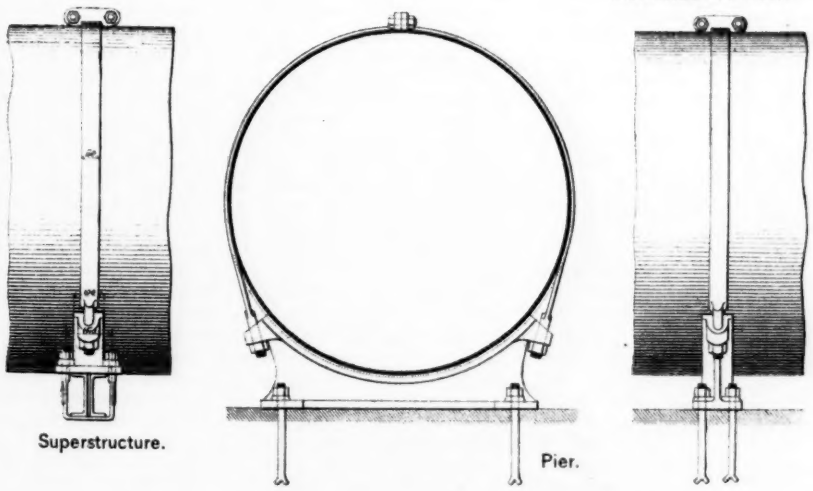


FIG. 8. METHOD OF SUPPORTING PIPE UPON PIERS AND SUPERSTRUCTURE.

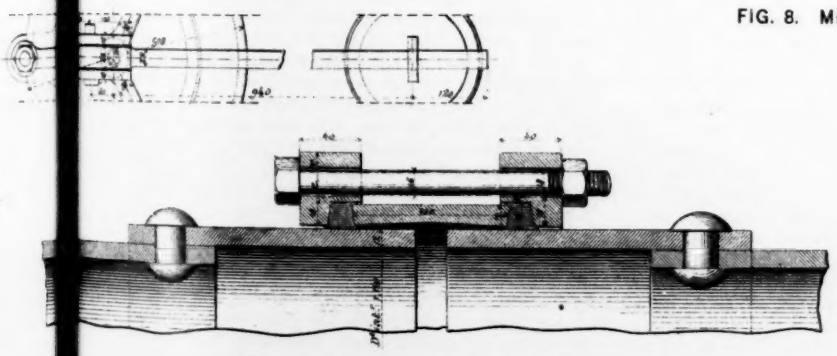


FIG. 7. THE GIBAULT PIPE-JOINT.

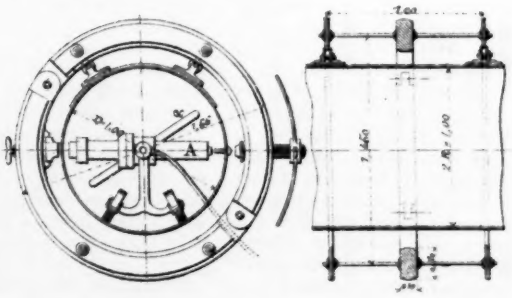
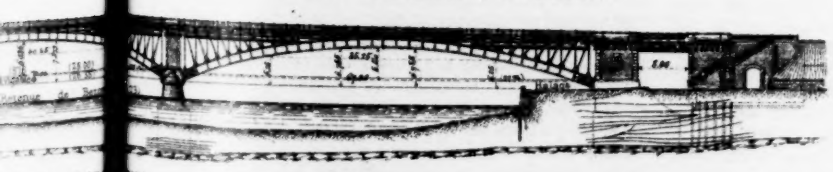


FIG. 11. HYDRAULIC RIVETING APPARATUS.



EDUCT AT AR UIL.

ARMS FO HE DISPOSAL OF THE SEWAGE OF PARIS.

Messrs. Bechmann and Launay, Engineers.

CHAS. HART & SONS, LITH., 95 VESEY ST., N. Y.

Among the special apparatus employed at Acheres were pressure-reducers, so designed as automatically to reduce the flow of water in the first and second distribution zones of the farm, and yet leave passage for any sudden and unexpected flow. These reducers were made of two distinct parts, united by a pipe 0.60 m. diameter. The first part contained a flap-valve, 1.97 ft. diameter, movable by hand, but also connected with a piston which worked automatically under a head of 95 ft. The second part included an automatic balanced valve, 1.97 ft. diameter, which acts as a hydraulic balance under oscillations provoked by variations of water pressure, but so arranged as to not permit the down-stream flow to exceed a head of 115 ft. The flap-valve opens freely as soon as the overflow level is reached in the valve-chamber, and the balanced valve limits the pressure upon the distribution conduits down to a head of 32.8 ft. In practice, however, this pressure reducer does not work very well, as matter in suspension sometimes interferes with its operation, and the too sudden closing of the balanced valve causes a violent water-hammer. So far, also, the steel and cement conduits have resisted the heaviest pressures coming upon the first and second zones of elevation, and it is believed that they would as successfully resist those coming on the third and fourth, or the lower belts. The pressure reducer would thus be unnecessary.

The automatic distribution valve is shown in Fig. 2. This is made up of three separate parts, as follows: (1). A cylinder, with a bottom flange connecting it with the conduit, and on the outside of which are two projections for attaching the pressure device. (2). A cast-iron cover, with a rubber joint, resting upon the upper edge of the cylinder, and supporting the lever of the pressure device. (3). The lever arm, with a moveable weight. This valve is set to flow as soon as the maximum pressure touches 115 ft. Another distribution valve is shown in Fig. 3, in which the cast yoke carries a bronze pressure screw. This screw is regulated by hand, and no matter what the pressure may be in the conduit, the water escapes without velocity and flows onto the cemented surface placed around all of these valves. The cost of one of these latter valves is 42.50 francs, and in place the total cost is 220 francs, or $44, including the cement chamber and overflow and the vertical pipe connecting the valve and the distribution conduit.

In the original project for the Acheres sewage farm the quantity of sewage turned upon the land was not to exceed 110 cu. meters per day per hectare, or about 11,766 gallons per acre per day. This corresponds to a sheet of water per day, a little less than one-half inch deep, over the entire sewage farm of Acheres. When it is considered that nearly all this land is sand and gravel this relatively small quantity of water ought to be easily absorbed. On the other hand, as at Gennevilliers, this water is not distributed continuously; for the irrigation is intermittent, as is required for the satisfactory working of the system. All the flow of one day is concentrated upon one part of the surface, and the next day upon another, and so on until, as a fact, never more than one-third or one-fourth of the total surface is under treatment at one time, and the water does not return to the same point until after the expiration of three, four or five days, according to the crops.

This farm was put into operation in June, 1895, but the supply of sewage is not yet definitely regulated, and the building of conduits, clearing and preparing the land, and its proper drainage is only now being completed. From July to December, inclusive, in 1895, the total volume of water distributed was only 1,215,000,000 gallons, while for the same period in 1896 it reached 42,250,000,000 gallons, approaching the estimated maximum.

As a general conclusion, the permanent commission of five experts in charge of this work report most satisfactory progress, both in hygienic results and in operation. The soil under cultivation, and before sterile, is now fertile, and the water escaping from the underdrainage is practically pure. The entire cost of the system is 14,570,131 francs, or $2,914,026. This includes the lifting plants at Clichy and Colombes, the Clichy siphon under the Seine, the bridge at Argenteuil and the Herblay siphon, the aqueduct and the acquisition, drainage, buildings, roads and canals at Acheres and Fonceaux. The works were carried out under M. Huet, Director of Works, of Paris, and MM. Bechmann and Launay, respectively, Chief and Assistant Chief Engineer.

While this article is especially devoted to the irrigation farm itself, some other interesting features of the scheme are shown on our inset sheet which call for some brief explanation. The aqueduct bridge of Argenteuil (Fig. 6) is a graceful structure for the purpose intended. As shown on the general plan, Fig. 5, this bridge crosses the Seine near the lifting station at Colombes. It carries four riveted steel conduits, each 3.6 ft. diameter, laid under the floor of a bridge available for the passage of vehicles and foot-passengers; the roadway being 21.2 ft. wide, flanked on each side by footways, 5 ft. wide. The bridge is made up of two side-spans of 220 ft. each, between centers of hinges, and a center span of 229.6; the rise being 18.04 ft. for the side spans, and 19.7 ft. for the center span. This bridge was commenced on July 16, 1891, and opened to traffic on June 25, 1895. The total cost of the bridge and conduits was $309,584. The details of the conduit, and its joints and supports, are shown in Figs. 7 and 8.

At Herblay (see Fig. 5) the aqueduct again passes the Seine by means of a siphon, made of two riveted steel pipes, each 3.28 ft. diameter, and with a developed length of 341 ft. These pipes were connected at intervals of about 10 ft. by riveted, plate ties (Fig. 9), assembled upon the bank; and then hauled out and floated in the river over a trench dredged for them in the bottom and sunk by the aid of the piers shown in Fig. 10. Four of these launching piers were located in the river, 125.7 ft. apart, and supported upon piles. These were to be used in sinking and in aligning the pipes on the bottom, after they had been assembled and floated out. Sliding between two of the overhanging beams, and immediately over the pipes, was a heavy-framed "guillotine," operated by a block and fall and intended to guide the pipes in sinking. Before sinking these pipes were empty and closed at the ends by plates. Their weight was 185 tons, and the displacement of the completely submerged pipes was 270 tons; to sink them a surcharge of 85 tons was thus necessary, and it was deemed expedient to add 20 tons to this so as to assure and regulate the descent. This 105 tons was made up of railway rails, assembled in 100 bundles, and placed upon the plate-ties connecting the pipes by means of a floating crane. It should have been mentioned that, before sinking was commenced, two lines of sheet piling had been driven across the river, on the line of the pipe and 13 ft. apart, and on the bottom of the excavation previously made a bed of concrete had been laid for the reception of the pipe. When this had been done the upstream sheet-piling was cut away, as shown in Fig. 10, so as not to interfere with the launching and floating of the pipe. All these preparations having been made, the pipes were sunk in eight hours by a careful manipulation of the lowering tackle; a diver then removed the plates closing the pipes; the rails were lifted; concrete was deposited upon the pipes in such manner as to completely enclose them; and loose stone filled in the space between the outside of the sheet-piling and the excavation in the bottom of the river.

The riveting of the steel pipes was performed by a G. Le Blanc hydraulic riveter, applied to the pipes, as shown in Fig. 11. This appliance is made up of two parts; the hydraulic riveter, supported upon a four-wheeled rolling frame, and capable of being turned on its central axis over the whole circle of 360°, and a heavy, concentric ring, outside the pipe, to take up the shock of the blow and assist in forming the hot rivet. The cylinder of the hydraulic riveter enclosed two pistons; with the hydraulic power admitted between them, and so controlled by a valve that either end of the riveter could be operated at will. The heavy outer ring was made in two parts, connected by lock joints, and it was held in place by two flanking and lighter bands supported by two sets of rollers attached to a saddle resting upon the top of the pipe. In the heavy ring was a screw, carrying a die for the rivet-head; and diametrically opposite to this screw was a block, operated also by a screw, which could be brought into close contact with the outside of the pipe. As the free end of the riveter could be brought to bear upon the inside of the pipe opposite this block, ample resistance was provided for making the rivet-head at the other end, without any undue strain upon the pipe-plates. The hydraulic pump operating this riveter was of simple design, worked by hand and directly connected by a pipe to the riveter; this pipe passing through a rivet-hole left out at each joint; this rivet being afterwards put in by hand.

The crossing of the Seine, at Clichy, is made by means of a siphon-tunnel, completed in 1894. This tunnel is 8.2 ft. in inside diameter; is 1,518 ft. long and is 49 ft. below the general surface of the river. It was constructed by Mr. J. Berlier, at his own risk, upon practically the same plan as was pursued at the City and Southwark tunnel, in London, or by the so-called Greathead shield system. The tunnel is lined with cast-iron segments, with inside flanges, coated inside and out with cement. The shield used was 4 ft. long, provided with a cutting-edge, and was pushed forward by five hydraulic jacks after each ring of plates, 20 ins. wide, had been bolted in place. A progress of 8 ft. in 24 hours was sometimes made. The material penetrated was mud, running sand, flints and conglomerates, some of which had to be blown up by dynamite, and much water was met with, requiring the use of compressed air. Mr. Berlier took the work at his own risk and under a forfeit of $200,000 for failure. His contract price was $122 per lin. ft., including the vertical shafts fixing the ends of the tunnel, or 1,607 ft. in total length.

STEEL TANK GRAIN ELEVATORS "ELECTRIC" AND "FORT WILLIAM."

Among the important commercial structures in which steel construction bids fair to supersede brick and wood are storage elevators for grain, scores of which line the wharves of our large lake and ocean ports. Within the past twelve months no less than four grain elevators, having a capacity of from 1,000,000 to 3,000,000 bushels of grain each, have been built either wholly or partly of steel. The most expensive, and perhaps the best known of these elevators is the "Great Northern," erected at Buffalo, N. Y., by the Great Northern Ry., and having a capacity of 3,000,000 bushels. This structure will be described in a future issue, however, and at present attention will be directed to the two most recent of the other three structures, all of which were built by the Steel Storage & Elevator Construction Co., of Buffalo, N. Y. The first of these elevators is the "Electric," erected last year at Buffalo, N. Y., and the second is the 3,000,000-bushel structure now under construction for the Canadian Pacific Ry. at Fort William, Ont.

The elevator "Electric" takes its name from the fact that it is operated by electric power from Niagara Falls. It has a capacity of 1,000,000 bushels of grain, and cost in round figures $200,000. As will be seen from the accompanying view of the completed structure, it consists of a main building with one movable and one stationary tower, and 19 cylindrical steel tanks in which the grain is stored. The main building is 38 × 126 ft. × 146 ft. high, the movable tower is 24 × 32 ft. × 146 ft. high, and the stationary tower is 28 × 32 ft. × 146 ft. high. A belt gallery 17 ft. wide, 204 ft. long, and 70 ft. high, connects the main building with the storage tanks. Seven of these storage tanks are of 100,000 bushels capacity each, and the remaining twelve are of 25,000 bushels capacity each. Four of the smaller tanks are also divided into four compartments each. All the tanks are air-tight, and have self-cleaning hopper bottoms.

All the operating machinery is located in the main building, as also are the scales for weighing the grain. This building has a steel framework covered with corrugated steel, and is thoroughly fireproof. The grain is handled by rubber belt conveyors operated by electric motors varying from 40 HP. to 75 HP. each, and having an aggregate capacity of 450 HP. The current is received from the Niagara Power Co., and enters the building over two wires, where, by means of Westinghouse self-cooling transformers, it is changed from a 2,200-volt, three-phase, to a 200-volt, two-phase, current for use in the motors. These motors are of the Tesla induction type and were, with all the

other electrical equipment, built by the Westinghouse Electric Co.

As stated, the capacity of the elevator "Electric" is 1,000,000 bushels, but the site is large enough to allow its extension to 4,000,000 bushels simply by adding to the number of tanks. The elevator's receiving capacity from vessels is 24,000 bushels per hour, and its shipping capacity to canal boats and cars is 20,000 bushels per hour. Owing to its fireproof construction no insurance is kept on the building or on its contents.

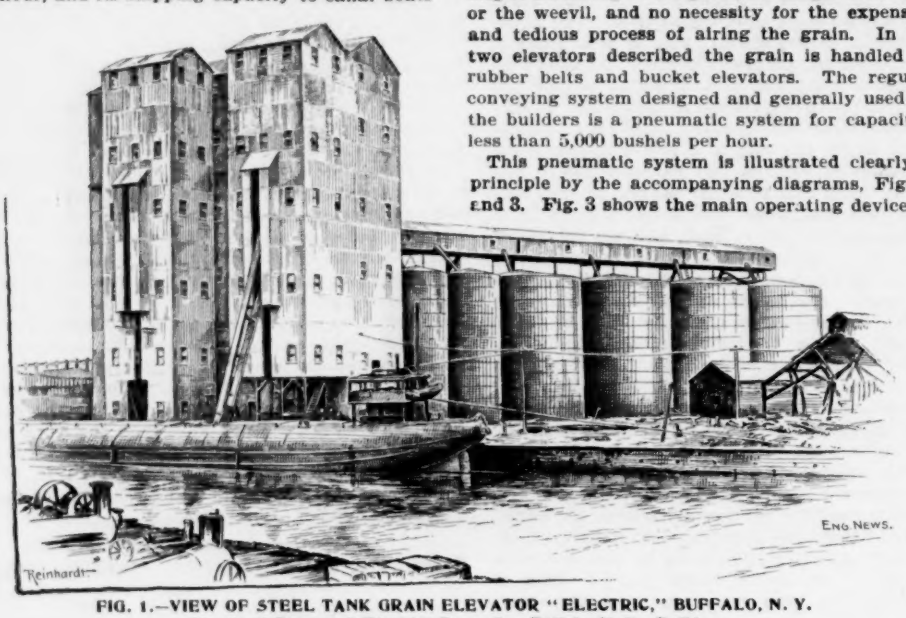


FIG. 1.—VIEW OF STEEL TANK GRAIN ELEVATOR "ELECTRIC," BUFFALO, N. Y.
The Steel Storage & Elevator Cons. Co., Buffalo, N. Y., Builders.

The "Fort William" elevator resembles in its general appearance the structure just described, but as it has a capacity three times as great, the number and size of the tanks are considerably increased. Altogether there are 16 tanks, 58 ft. in diameter and 60 ft. high, placed in two parallel rows, and 32 tanks 29 ft. in diameter and 60 ft. high, placed in two parallel rows between the rows of larger tanks. Two belt galleries extend over the tanks and contain belt conveyors and trippers for distributing the grain to the various tanks. Underneath the tanks are two tunnels constructed of stone which contain the conveyors for transferring the grain from the tanks to the main building, where it is weighed.

The main building has a steel framework, steel plate floors and corrugated steel covering, and it contains the circular steel garners, steel elevator legs, power shovels, car pullers, warehouse separators, steel spouting, and the transmission machinery. The boiler and engine house is a separate building constructed of stone, and it contains three 66 ins. × 16 ft. boilers and a 400-HP. condensing engine. The power is transmitted from the engine to the main house by a 400-HP. manilla rope drive.

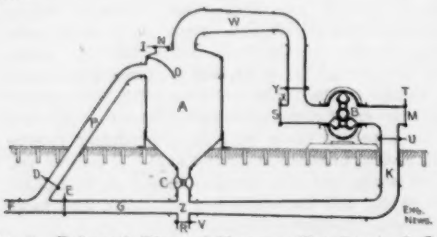


Fig. 3.—Enlarged View of Vacuum Chamber and Connections in Pneumatic System for Handling Grain.

This is the fourth elevator to be erected by the Canadian Pacific Ry. at Fort William, which is situated on the Kaministiquia River, about 1½ miles from Thunder Bay, an arm of Lake Superior. Each of the three other elevators has a capacity of 1,250,000 bushels of grain, and is built of wood. The company will carry no insurance on the new steel elevator.

It will be seen from the brief descriptions which have preceded that the characteristic features of this type of elevator construction are the complete separation of the operating and storage departments, and the use of steel, air-tight storage tanks. By separating the storage and operating departments the task of increasing the capacity of the elevator consists simply in the addition of new tanks to those already built, while by using air-tight tanks it is claimed that there is no rotting or shrinking of the grain, no danger from rats or the weevil, and no necessity for the expensive and tedious process of airing the grain. In the two elevators described the grain is handled by rubber belts and bucket elevators. The regular conveying system designed and generally used by the builders is a pneumatic system for capacities less than 5,000 bushels per hour.

This pneumatic system is illustrated clearly in principle by the accompanying diagrams, Figs. 2 and 3. Fig. 3 shows the main operating device located in the elevator house to a large scale. In this device A is an air-tight receiver or vacuum chamber with a hopper bottom and the necessary openings. Underneath the receiver is a continuous feed device, C, which is operated by means of a belt from a pulley on the line shaft. The blast-pipe K, leading to point of discharge under the receiver, is made tapering for the purpose of increasing the force of the air-current, created by blower B, which always runs in same direction, whether grain is being transferred to or from the storage tanks.

In the operation of conveying grain from mill or elevator building to the storage tanks, the valve on the top of the receiver is opened, allowing the grain to enter through the opening N. (The grain can be delivered to this point by the same means of elevating as is necessary to elevate the grain into the stock-bins.) By opening valves X, U, and E, and closing valves T, V, Y, and D, with the blower taking air through the opening S, we have the current going in the proper direction for transferring grain to the storage tanks. After the grain has entered the receiver A, and passed through the feed device C, it comes in contact with a blast-current, by which it is carried through the grain-pipes G and F out to the storage tanks, entering them at the top.

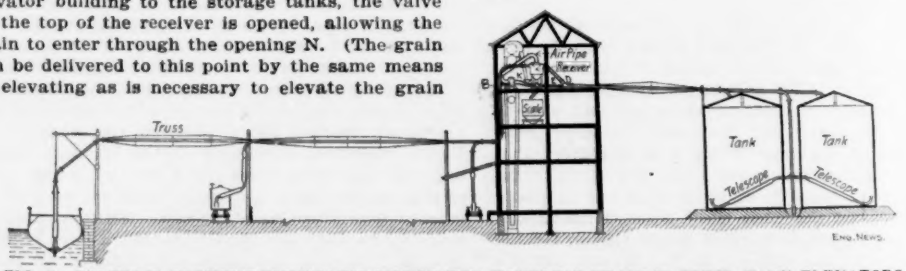


FIG. 2.—DIAGRAM SHOWING PNEUMATIC SIPHON FOR HANDLING GRAIN IN STEEL TANK ELEVATORS.

In the operation of transferring grain from storage tanks to mill building, valves D, T, V, and Y are opened, while valves E, I, U, and X are closed, which changes the air-current from blast to suction, the blower now taking air at point between the storage tanks, together with the grain entering receiver A through grain-pipes F and P, again passing through feed device C and Z, passing out at opening R, where it can be spouted into stock-bins, hopper scales, or wherever desired, while upon entering the receiver, the light dust and air passes around baffle-plate O, through air-pipe W and blower B, out of the opening M, either into the dust-collector or out of the building.

It will be seen from Fig. 2 how these same operations load or unload the grain to and from vessels, cars or wagons. A large number of these pneumatic systems are in operation in grain elevators built by the Steel Storage Elevator Construction Co., and are stated to have given full satisfaction.

For the information from which this description has been prepared we are indebted to Mr. V. E. Winn, Chief Engineer, Steel Storage & Elevator Construction Co., Buffalo, N. Y.

THE DIESEL MOTOR.*

By E. D. Meier, M. Am. Soc. M. E.

Since a scientific investigation of the working of the steam engine began, it has been apparent that it is badly deficient in economy. In the best types of triple-expansion engines, supplied by the best boilers, and managed with the greatest care, we can realize only about 12% of the potential energy of the coal we burn; while in the ordinary engines in most general use in thousands of manufactories we must be satisfied with 6 to 8%, and again, in many millions of small engines in use as auxiliary machines, such as steam pumps, etc., we realize hardly 2% of the heat available in the fuel. Improvements in boilers and furnaces have gone about as far as is possible, and these sources of power put as high as 75 and 80% of the fuel value into the main steam pipe. The balance of the enormous loss above quoted is in the engine itself. The sources of loss are well known, but the remedies cannot be supplied with the means at the command of the engineer.

[The "Zeitschrift des Vereines deutscher Ingenieure," of July 10, 17 and 24, 1897, contained a long paper, with drawings, on the Diesel oil engine, and a summarized translation of the paper, by Bryan Donkin, M. Inst. C. E., appeared in the "Engineer" (London), of Oct. 15, 1897, with the illustrations, which we herewith reproduce.—Ed. Eng. News.]

The first attempts to obtain power from the explosive force of gases or oil vapors date from the end of the 17th century, and the names of Haute-Feuille, Huyghens and Papin are recalled as the pioneers in this work. [Here follows a summary of the history of the experimental stage of the gas engine, from 1791 to 1857.—Ed.]

In 1857 Barsanti and Matteucci built the first free piston engine, in which the explosion throws up a heavy piston, and the returning weight and a partial vacuum, by means of rachet and pawls, transmit motion to a shaft.

This closes the experimental stage of these motors, and in 1860 Lenoir, in Paris, brought out a successful type of which many were built. They take in gas and air at atmospheric pressure and explode by electric spark. Lenoir believed that a slower explosion would increase his economy, and even proposed stratification of the charge.

Dugald Clerk says:

It is somewhat extraordinary to find notions so erroneous common at a time when Bunsen's work had clearly proved the continuous nature of the combustion in gaseous explosions, and when Hirn had made experiments which showed that the heat evolved by explosion in a gas engine was only a small part of the total heat of the combustion, the heat which did not appear during explosion being produced during expansion.

Other speculations on the cause of the uneconomical working of the engine were frequent, but the true reason was fully explained by Gustav Schmidt in a paper read before the Society of German Engineers, in 1861. He states: "The results would be far more favorable if compression pumps, worked from the engine, compressed the cold air and cold gas to three atmospheres before entrance into the cylinder; by this a greater expansion and transformation of heat is possible." This opinion became common at this time. Compression engines were proposed with great clearness and a full understanding of the advantages to be gained.

In 1862 Beau de Rochas first proposed the cycle now generally known as the Otto cycle, composed of four single strokes, viz.: 1. Suction during an entire out-stroke. 2. Compression during in-stroke. 3. Ignition at dead point and expanding during next out-stroke. 4. Exhaust of burnt gases during next in-stroke.

*Condensed from a paper read at the Washington meeting of the American Society of Naval Engineers, Jan., 1898.

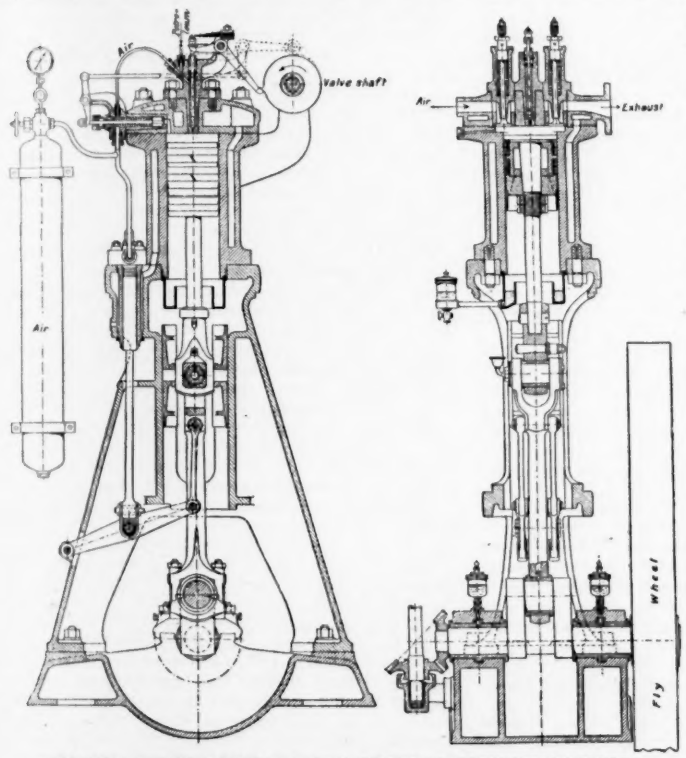
He also proposed to supplant all igniting devices by obtaining spontaneous ignition from a compression of the charge to one-fourth of original volume (318.2° F.).

In 1867 Otto and Langen constructed a free piston engine on the same lines as Barsanti and Matteucci, but which, by reason of better working out of mechanical details, became a commercial success.

The first practical benzine or naphtha engine was built by Hock, in Vienna, in 1870, and in 1872 Brayton, in Exeter, N. H., built the first engine using ordinary lamp petroleum of 0.85 gravity, which was also the first oil engine using combustion at constant pressure; but only 6% of the heat was utilized.

In 1876 the Otto silent engine, with the first practical application of the Beau de Rochas cycle, and compression before explosion, was brought out and soon dominated the field. Since then improvements have been in matters of detail only, and after the expiration of the Otto master-patent this type was adopted by all builders of gas or oil engines. The names best known in connection with these improvements are Crossley, Atkinson, Hornsby, Tangye, Priestman, Capitaine and Clerk.

The heat efficiency as measured in brake horse-power has slowly risen from the 6% of Brayton in 1873 to 14½% in 1888, about 18% in 1890, 21.25% in 1894, to the highest result obtained on a 100-HP. Otto gas engine, by Prof. Spangler, in 1895, viz., 23½%. Much confusion is created by quoting efficiency as referred to I. HP. This is the



SECTIONAL VIEWS OF THE DIESEL INTERNAL COMBUSTION MOTOR.
(Reproduced from "The Engineer," London.)

usual and convenient method employed for steam engines, where the total friction losses are generally conceded to range between 10 and 13%. In the case of gas and oil engines the limits are not so well defined, and generally range higher, say between 16 and 25%, and in some cases even more. The only rational way, therefore, of comparing motors of such great variation in type is to refer all efficiency to the brake horse-power. Another thing must be considered in comparing a steam engine with a gas engine: It would not be fair to the former to refer the efficiency of the gas engine to the heat units present in the gas. Just as the steam engine is charged with the loss in its necessary adjuncts, boiler and furnace, so the gas engine should be referred back to the actual coal, thus covering the losses in the gas producing plant. This shows the best present gas engine economy from coal to range between 17 and 19%, the higher results being only reached with large engines and with all conditions very favorable. The best builders will not guarantee higher than 17% from coal. For oil engines the best results are about as follows:

Name.	Year.	Lbs. per B.HP. per Hr.	Actual efficiency per B.HP.
Priestman	1891	0.84	0.15
Hornsby	1894	0.97	0.14
Trusty	1894	0.82	0.16
Crossley-Otto	1894	0.82	0.16
Deutz-Otto	....	0.96	0.15
Grob-Capitaine	1894	0.59	0.21

The last result is a solitary result high above the average of good engines of this type, and in this case the fuel value of the oil is reported as rather low, both facts giving color to the suspicion of an error somewhere in the report. We may conclude then that the highest results attainable for the three types of engines in average good practice are 12% for the steam engine, 16% for the oil engine, and 18% for the gas engine, all figured from the actual heat value of the coal or oil to the effective or brake horse-power.

Within the last decade the increase in the number of gas and oil engines sold has been remarkable and there are now upwards of three hundred firms in Europe and America engaged in their manufacture. Gas engines are built up to 400 HP. each, and oil engines up to about 100 HP. The highest pressures used are about the same as in the latest steam engines. But the dangers and breakages incident to parts overheated for the purpose of ignition, the repetition of shocks due to the explosions, making excessively heavy working parts necessary, the large fly-wheel required for the four-stroke cycle and the difficulty of governing have combined to prevent building of such large units as are usual in steam engine practice. It seems that a still greater step forward in economy must be made before that which the prophets have foretold, the gradual supplanting of the steam engine by the hot air motor, can take place.

This step has now been taken by Rudolph Diesel, a brilliant young engineer of Munich, Germany. It has been taken after a most conscientious and exhausting study of the problems to which he has devoted fifteen years of his life. For a better understanding of the steps by which he reached his success, a short statement of the difficulties and methods of previous practice will be of advantage. While it is usual and proper to distinguish between gas and oil engines, we may group them together for this purpose, since before the oil is brought to combustion or explosion it is first vaporized and this vapor mixed with air to form an inflammable charge just as in the case of the gas engine. We have:

I. Engines igniting at constant volume, but without previous compression.
II. Engines igniting at constant pressure with previous compression.
III. Engines igniting at constant volume with previous compression.

In the first there is really a subtype, the free piston engine, in which the sudden and unchecked expansion goes to below atmospheric pressure and creates a vacuum for the back stroke, but this type is now obsolete. This type has the disadvantage that at most 60 to 100 lbs. initial pressure can be obtained, that the slightest throttling in suction or exhaust is ruinous to economy, and that very long strokes are necessary to obtain sufficient expansion.

The second type has the disadvantage that the conditions of its success are that there should be no heat gained and no throttling while charging and no throttling or heat lost while entering the motor cylinder, no back pressure during exhaust, and no clearance in the motor cylinder, all conditions impracticable to realize.

The third type is the one which has persisted. Its difficulties are mainly the questions of governing, of ignition and of clearance. The clearance space in such an engine is necessarily large, because igniting devices must be introduced therein, and the combustion chamber must be apart from the working section of the cylinder, for the great heat therein generated makes lubrication impossible. This clearance sometimes runs as high as 30%, leaving only 70% of the total volume for the working cylinder. The objection to this clearance in reducing the effect of the expansion is the same as in the steam engine. While there is nothing akin to cylinder condensation to be increased by this clearance space, there is another serious objection to it in its containing a volume of spent gases at the end of the in-stroke which will dilute the entering charge and render its exact composition doubtful.

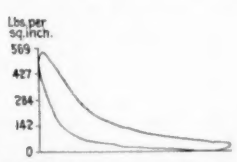
The ingenious method of Atkinson, called scavenging, by which the first inrush of fresh air is made to sweep out this spent gas is partly successful, and other devices with varying degrees of success have been employed, without, however, eliminating the difficulty. Compression before explosion is now generally recognized as a great advantage; it makes greater initial pressure from explosion possible; it makes the charge more easily inflammable, and it adds heat, and both assist the ignition device which may be used; in some cases a special ignition tube has been been discarded, it being found that with these effects of compression the walls of the combustion chamber, or the vaporizer, were in themselves sufficiently hot to ignite the charge. This great clearance does harm in another way; for every kind of oil vapor or gas there is a certain best mixture, i. e., the one which will give the highest pressure of explosion. Now, as the amount of clearance space fixes the total volume of the charge at the dead point it naturally exactly limits the amount of fuel which should be mixed with the air, and this increases the difficulties of governing. In the vast majority of engines governing is done on the hit-and-miss way, i. e., by injecting a full charge of fuel at normal speed or less than speed, and cutting off the supply entirely when the speed is too great. This makes it impossible to avoid irregularities in speed. Other methods, such as holding open the exhaust valve longer so as to reduce the entire volume of air in the cylinder of course reduces the amount of previous compression and hence the amount of initial pressure and the effect of expansion.

All igniting devices have their objections. The electric spark often fails to ignite, the direct flame is so uncertain and objectionable that it has been discarded. The hot tube is apt to wear out or even burst, and the red hot end to a cylinder is inconvenient and necessarily short lived.

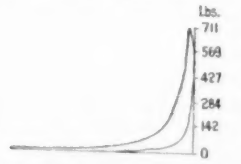
Another drawback incident to large clearance and the necessity of exact proportions between the fuel and air is that the consumption per horse-power grows rapidly, much more so than in the case of the steam engine, when the load is reduced. The highest efficiencies reported are only possible when the engine is working at its rated capacity under a constant load.

All internal combustion motors, however carefully designed, have the one defect in common that once the charge is ignited the combustion or explosion is beyond control whether as to temperature or pressure.

This was then the condition of the problem as Diesel found it. His invention consists first in carrying compression to its rational highest limit by compressing the air separately from the fuel, and hence to a pressure and temperature far above the igniting point of the fuel. While others are limited as to the amount of air they may admit he not only uses but utilizes a complete cyl-



Indicator Diagram of Engine Cylinder Full Power Test.



Indicator Diagram of Air Pump Cylinder.

inder volume of air. He then injects the oil or gas at a slightly higher pressure, he introduces it just at the point desired and continues its introduction during either a predetermined or a variable portion of the stroke; and his great advantage is in absolute control of the temperature, pressure and duration of combustion. As he is enabled to carry an entire cylinder full of air he has an excess of oxygen present and his combustion is perfect and complete. Requiring no igniting device, as every charge ignites spontaneously, the hottest portion of the cylinder, the small clearance space used as a combustion chamber, can be kept cool, instead of requiring to be extremely hot. There is no shock of explosion, but the compression rises on an adiabatic curve to practically the highest point, and combustion proceeds with no essential increase of temperature, the added heat being immediately transmuted into work down to the point of cut-off, whence adiabatic expansion is carried as far as is consistent with rapid and certain exhaust. We have therefore in the Diesel motor all points which previous inventors and investigators have longed for, the compression of De Rochas, of Schmidt and of Clerk, the slow combustion of Lenoir and of Otto, and the practically complete discharge of the spent gases of Crossley and Atkinson, the excess of air being large and the clearance small.

Besides this we have the reduction of the temperature of combustion to far below that of previous internal combustion engines. In 1893 Diesel published a pamphlet, translated into English in the same year by Mr. Bryan Donkin, entitled "The Theory and Construction of a Rational Heat Motor to Replace Steam Engines and Internal Combustion Motors." The criticism of this book by German engineers and professors was so favorable that the large corporations of the Augsburg Machine Works and Frederick Krupp in Essen united in offering Mr. Diesel means, facilities and men to work out his theory in practice. In consequence the first 12-HP. motor was completed in Augsburg in 1894, and experiments, tests and changes were made on the same in the sacredly guarded precincts of a special testing room, the results of which were carefully tabulated and discussed by Mr. Diesel and a well selected corps of practical experts. As the result of all this a second motor of 20-HP. was planned and built, and placed on the foundations of the first one in October, 1896. This has since been running

almost constantly ten hours each day. On April 27, and 28, 1897, Mr. Diesel published his results by lecture and practical demonstration in the presence of a large circle of mechanical experts, both at Augsburg and at Munich, Prof. Schroeter, of the Technical College of Munich, assisting him by a brilliant exposition of the theories involved. Prof. Alfred Musil, of the Technical College of Brunn, Germany, who was present, writes as follows:

These two days will without doubt become red letter days in the history of our modern machine building, for the success which Diesel has so far achieved with his motor is already so brilliant, the fuel consumption during the perfect working of the machine is so small in comparison to all other heat motors that in spite of all former opposing prophesies, the Diesel motor is not only in full justice entitled to the name of a "Rational Heat Motor," but may be fitly called the "Source of Power for the Future." The inventor is entitled to the unreservel acknowledgment and gratitude of his contemporaries.

On June 16, 1897, Mr. Diesel delivered an address fully explaining the construction, the working and economy of his motor before a convention of engineering societies of Germany at Kassel. He was followed by Prof. Schroeter in an essay developing the theory of the motor. Both papers were received with the greatest applause, and engineers who had been sent there to carp and criticise came back as apostles of Diesel's ideas. Mr. Diesel ended by inviting all interested in the subject to visit the works at Augsburg, and make their own tests and examinations. This invitation was followed by many engineers from German, England, France, Belgium, Austria and Italy, and even Russia.

It was my privilege to meet Mr. Diesel and visit with him the works at Augsburg, where this first successful motor is running, during the latter half of September, and to confer with him later in Munich, Nuernberg and Frankfort in company with a number of the leading men interested in machine building in Germany. No question regarding his motor which doubt could suggest or ingenuity devise remained unanswered. It seemed impossible to bring up any problem which had not previously occurred to him or his assistants and had been worked out in every detail to a final solution. At Augsburg I was allowed to choose my own assistant and adviser, which I did in the person of an eminent practical engineer of Nuernberg, Mr. G. Marx, chief engineer of a rival establishment. I was permitted to choose my own time, and then the motor, the instruments, the fuel supply, were turned over to me, and a force of intelligent engineers and machinists were instructed to obey no orders but mine.

I saw the motor at work on Sept. 27, 28, 29 and 30. In the course of my investigations during these four days I took frequent occasion to question the erecting engineer, Mr. Schmucker, about various points, the answer to which would involve the question of the time since it has been in operation, and the continuity of its service. It was completed in October, 1896, and many changes and alterations were made during the next three months, but its operation has been practically continuous for ten hours a day since the first of February. During these past eight months a number of people have been in to see it in operation, have had it taken apart and put together again for their inspection. Judging from what I saw during the time I was at the works there has been no time to do any special cleaning, or any repairs, except of a very trivial nature. Official tests were run on Feb. 1, 4, 12 and 17, March 17, April 30 and May 1. On Sept. 30 Chief Engineer G. Marx and I ran a short test with Messrs. Reichenbach and Boettcher. These tests all point one way. They vary just sufficiently to show the independent work of the various observers and the differing conditions under which they were made. Some find better thermic and some better mechanical results than others. In general the later results are better than the earlier ones. The consumption of petroleum per effective (or brake) horse-power, when running at or near full power, varies from 215 and 218 grammes per hour as found in some tests by the Augsburg people to as high as 242 grammes as found by the French engineers on May 1, 1897. Mr. Marx and I found a consumption of only 223 grammes per effective horse-power hour. The commercial or final economy of the machine when running at or near its rating varies from about 25% to nearly 29%. In general the larger and better results are the later ones, showing that instead of losing by wear and tear, as some engineers had predicted, it is increasing in efficiency, as most steam engines do after they get down to their bearings. The consumption of oil for cylinder lubrication is only one-third litre in ten hours, considerably less than 0.1 gallon. This small consumption is due to the fact that the lubricant is introduced around the sides of the cylinder at a point level with the lowest position of the upper packing ring. The oil remains on the surface entirely, and that large amount which in a steam engine, where it is introduced through the steam pipe, is lost with the exhaust, is saved in the Diesel motor. We had a number of indicator cards taken, both from the air cylinder and the air pump, and they correspond very closely to the later series published in Diesel's paper. In starting the motor after it has been stopped, two successive charges of compressed air are admitted from the air vessel, and after this the valve mechanism is thrown into gear and the regular work of combustion commences. As the air pump at all times keeps this air vessel fully charged with compressed air, there is always an ample supply for starting on hand after the motor has been stopped. In case the motor is run with gas instead of petroleum, the air pump, instead of compressing air, compresses this fuel gas, so that in that case a supply of compressed gas is always available. The amount of petroleum injected at each charge is regulated by the governor, which acts on the valve, by moving a long, thin wedge under a spring-guarded plunger, which moves with the petroleum pump. The prompt and efficient action of this governor was apparent when the weights on the pan of the Prony brake were removed or replaced successively.

The air pump and the main cylinder, as well as the valve chambers, which are placed in the cylinder head, are cooled by water jackets, and the water discharged from the same is about four gallons per minute, and its temperature is less than 100° F. This is only about one-sixth of the amount of water used by a condensing steam engine. I examined the interior of the cylinder, the suction and exhaust and petroleum valves twice, once on Sept. 28 and once on Sept. 30, and in each case within 15 minutes after stopping. There was practically no evidence of wear. The arrangement for injecting the petroleum is cleverly devised for distributing it in a spray very thoroughly throughout the combustion chamber. I examined the valve and the nozzle very carefully in each case and found them perfectly clear. Whether they would work as well with Lima oil or fuel oil, experiment only can determine, but as the oil will alway be hot before it reaches the nozzle, it will be in its most fluid state, and I anticipate no difficulty in blowing it in.

When at work the motor is practically noiseless. The oiling of the moving parts is well managed by good self-feeding oil cups and a series of small pipes, as is now the practice with good steam engines.

Both at Augsburg and at Nuernberg they are putting the works on about six of these 20-HP. motors, so that within a few weeks each factory will have two perfect perfect motors on exhibit. It is their intention then to have one motor running at all times, driving a part of the shafting of the works, and another one standing ready for experiments or examination by visitors.

There have been a number of tests made of the motor by experts from Germany, France and Switzerland. I give the principal results of these tests in tabular form below. The motor is rated at 20-HP. on the Metric Standard. Ordinarily we class engines according to their indicated horse-power, which is generally from 10 to 14% greater than the brake horse-power, the difference being absorbed by the machine itself. This motor when run at its rating indicates about 25-HP. on the average. The friction losses in the engine are somewhat greater than in a good steam engine, but its effective or brake horse-power is about the same as that of a good steam engine of 20-HP. The table below shows the principal results of six tests made by different observers. These tests were run by Mr. Dyckhoff and Mr. Diesel for the French Co. which has since beea organized under the name of the French Diesel Motor Co.; Messrs. Stein and Diesel for the Deutz Gas Motor Co.; by Messrs Sultzer and Diesel for the Sulzer Bros., of Winterthur, Switzerland; by Professors Schroeter, Brueckner, Munckart, of the Munich Polytechnic School; by Messrs. Carle, Merceron and Sauvage, of Paris, for the French Diesel Motor Co., and by Chief Engineer Marx and myself for the American interest. I give at the head of each column the name of one observer in each case, by which the test can be located by reference to the schedule above given. The horizontal lines are numbered, 1 gives the date, 2 the number of revolutions per minute, 3 the indicated horse-power, 4 the effective horse-power, 5 the number of grammes of petroleum per hour for each effective horse-power, and 6 the final or commercial efficiency in per cent.

All other data I shall be glad to furnish by reference to copies of the tests themselves, which I have on file:

Results of Economy Tests of the Diesel Motor.

	Dyck-hoff.	Deutz.	Sulzer.	Schroe-ter.	Carle.	Marx.
1.....	Feb. 1, 1897.	Feb. 4, 1897.	Feb. 12, 1897.	Feb.17, 1897.	Apr. 30, 1897.	Spt. 30, 1897.
2 163	152	161.4	154	165	166.2
3 ..... 24.10	23.15	25.4	24.7	26.7	26.6
4 ..... 18.84	17.50	18.61	17.8	19.1	19.2
5* .....234 gr.	238 gr.	242 gr.	238 gr.	242 gr.	223 gr.
6 ..... 26%	26.2%	26.6%	26.2%	25.6%	28.6%

*The average of these is 236 grammes, or 0.52 lb. per B. HP. per hour.—Ed. Eng. News.

There were a number of tests run by the various observers on the motor running at or about half its regular load, and even less, with a view to determining its economy under such conditions. It is well known that a steam engine running at considerably less than its normal or rated load loses very much of its economy. This is evidently not the case with the Diesel motor. The lowest percentage of commercial efficiency found under such circumstances was 21.5, and various observers found it from this up to 24.1%. An average of all results gives about 23% at half load.

I have preserved a number of indicator cards made during our test, which have been run over by planimeter both by Mr. Marx and Mr. Boettcher. As these diagrams are necessarily very small, there is a little difference between the two observers, as would naturally be expected. The indicator used is a very nice and delicate instrument, made by Messrs. Schaeffer and Budenberg. For use with ordinary steam engines it has the regular size piston. For use on the Diesel motor it has a reduced piston of an area just one-quarter of the other. We must remember that our diagrams run up to 35 atmospheres. This will account for the slight difference in the calculations of the cards. In estimating the horse-power from these cards we must remember that only each fourth stroke is a working stroke, this being a four-beat machine.

Thus far neither the inventor nor the manufacturers claim any practical results on any other fuel but petroleum. They will make no statements except positive ones, and for those they require a whole series of experiments managed with great care and thoroughness. Besides ordinary petroleum they have, however, made extensive laboratory experiments with different kinds of natural oils, residual products of Russian petroleum, American gas oil, illuminating gas, producer gas, and even coal dust. The experiments are still going on, although naturally interrupted by the visiting delegations before mentioned.

A second motor of the same type and size is nearly completed and will be placed in the same testing-room, so that the practical tests on these various fuels can be made without danger of interruption, the first motor to be then used as an exhibit. Another motor having three cylinders and arranged for compound compression and compound expansion is completed and now in its experimental state. This is to run at 125 to 150 HP.

The interest created by this invention in Europe can only be likened to that occasioned in this country by the successful introduction of electrical light and power. Some of the largest and most important works have taken out licenses and are actually building motors of various types. The following is a partial list:

Augsburg Machine Works; Nuernberg Machine Works; Deutz Gas Motor Works; Sulzer Bros.,Winterthur, Switzerland; Friedrich Krupp, Essen; Friedrich Krupp, Magdeburg-Buckau; The Mirrlees, Watson & Yaryan Co., Glasgow; Societe Anonyme des Moteurs Diesel, Bar-le-Duc; Carels Feres, Ghent; Burmeister & Wains Machine & Shipbuilding Works, Copenhagen; Titan Machine Co., Copenhagen; Diesel Motor Works, Augsburg; H. Paucksch Machine Works, Landsberg.

An American company with large capital will be formed for the introduction of the Diesel motor during this month, and before the end of February a motor will be on exhibit and offered for tests in New York city.

While these first motors are only built for stationary purposes, railway motors, street car motors and marine motors have been designed by various firms above mentioned, and will probably all be completed and running during the year. A joint exposition by builders of the Diesel motor will take place in Munich in June or July, and this will comprise various types.

The Augsburg Machine Co. have begun the construction of a new addition to their immense works, solely for the building of Diesel motors. The sum of $600,000 has been assigned for this purpose, and all the machinery in these works is to be driven by Diesel motors. Privy-Councillor Buz, the President and General Manager of these works, a gentleman of large experience and sound judgment, stated to me that they would immediately begin building for large powers, and that he was convinced that he would have a Diesel motor of 800 or 1,000 HP. running at the Paris Exposition in 1900. In his opinion the supplanting of the steam engine for all purposes by the Diesel motor is a forgone conclusion, although it will be a matter of gradual development. That a motor which has none of the disadvantages of former gas and oil engines, and almost all the advantages of the steam engine, and which begins its career with an economy double that of the best triple expansion steam engine and 50% higher than the most highly developed types of gas and oil engines, gives a basis for such hopes and predictions cannot be doubted.

MOVING A 2,300-TON BRICK BUILDING BY CABLES AND WINDLASSES.

We illustrate herewith an ingenious plan adopted for moving a five-story brick tenement, 25 × 75 ft., by means of cables and windlasses. Ordinarily in moving buildings of brick construction screw jacks are used, as the movement has to be slow and steady to prevent disturbing the masonry, and such a motion is not easily secured with cables and windlasses. In the present work, as already stated, cables were successfully employed, but a special arrangement of the timbering and special attachments for distributing the pull were adopted. These are quite clearly shown by the drawings, Fig. 1 and Fig. 2.

Fig. 1 shows the arrangement of the timbering. Directly under the walls were placed the longitudinal timbers A, each 12 × 12 ins × 80 ft. These timbers rest on the transverse timbers B, which in turn rest on the screw timbers C. This portion of the timbering was placed before the building was raised. The screw jacks were then placed underneath the screw timbers C and the building raised

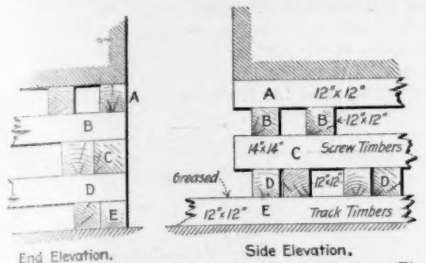


Fig. 1.—Sketch Showing Timbering Used in Moving a Five-Story Brick Building.

so as to allow the shoe timbers D and the track timbers E to be placed. Fig. 2 is a sketch plan of the timbers C, D and E, and shows the method of attaching the pulling chains. These chains are attached to the whiffletrees F and G, which are strong timbers pivoted at the center so as to have a horizontal swing, and which carry sheave blocks. There are seven of these blocks, and the "dead man," or anchor timber, H, it will be noticed, also carries seven blocks. Through these 14 blocks are sheaved four cables, each of which presses to a windlass located as shown. The windlasses were operated simultaneously by horse power.

The building which was moved in the manner above described is located on Elm St., New York city, and its moving was made necessary by the widening of that thoroughfare now in progress. Its total weight was 2,300 tons, and it was moved 32 ft. to the rear, and then raised 8 ins. Including the laying of the track timbers, 2½ days were taken to move the building and raise it. Nine hours were worked each day. The power required to pull the building is stated to have been 800 tons. The contractor for moving the building was Wellsworth K. Clynes, of 250 Varick St., Jersey City, N. J. We are indebted to him for the information from which this article has been prepared.

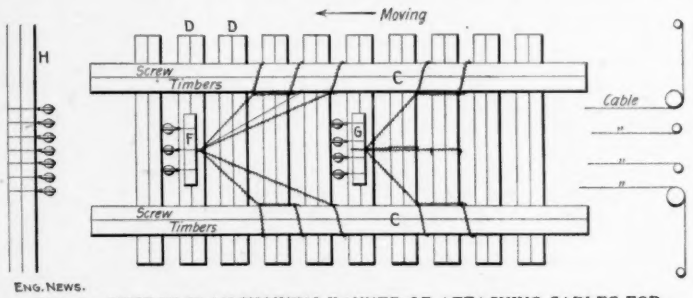


FIG. 2.—SKETCH PLAN SHOWING MANNER OF ATTACHING CABLES FOR MOVING A FIVE-STORY BRICK BUILDING.
W. C. Clynes, Jersey City, N. J., Contractor.

NOTES BY RAIL.

Chicago, Rock Island & Pacific Ry.

Track Elevation at Chicago.—This road has done considerable work in elevating its tracks, but the work commences at 16th St., and nothing has yet been decided as to raising the tracks between that point and the terminal station on Van Buren St. The elevation of the tracks at the complicated and dangerous crossing at 16th St., however, will require the C., R. I. & P. Ry. to continue its work furhter northward. The work is done in conjunction with the Lake Shore & Michigan Southern Ry., as both roads use the same terminal and run parallel on the same right of way as far as 61st St. (Edgewood). The work is in charge of Mr. L. H. Clarke, who is Engineer of Track Elevation for both roads. Up to the end of 1897, there had been 5.08 miles of road elevated, from 16th St. to 59th St., with 28 subways. The number of tracks was eight, as an average, and the total length of tracks elevated was 40.69 miles. The average amount of elevation was 10 ft., street grades being lowered to give the requisite headway at the subways, and the maximum grade is 16 ft. per mile. The contract for earthwork was let to the Knickerbocker Ice Co., which loaded the cars in the pit, all unloading and track raising being done by day work. The bridges are all through plate girder structures with solid floors, and the contractors included the American Bridge Works, the Lassig Bridge & Iron Works and the Chicago Bridge & Iron Co., all of Chicago, and the King Bridge Co., of Cleveland, O. The steel bridging included 184 spans, with a total length of 12,804 ft. The embankment amounted to 829,595 cu. yds.; the first-class masonry for abutments at streets, 28,827 cu. yds.; and the rubble masonry for retaining walls, 41,476 cu. yds. Ths approximate cost of this work was $1,500,000. Under the city ordinances now in force, there yet remain three miles of road to be elevated, from 59th St. to 72d St., on the C., R. I. & P. Ry., and from 59th St. to Keefe Ave., on the L. S. & M. S. Ry. The number of tracks ranges from 6 to 30, averaging about 15, or about 45 miles of track to be elevated. There will be 13 subways. The average amount of elevation will be 10 ft., and the maximum grade 16 ft. per mile. The cost is estimated at about $1,100,000, but the work is not yet under contract.

Standpipes at Water Stations.—At some of the water stations standpipes are to be erected in place of the present ordinary wooden tanks on timber or iron trestle towers. A standpipe 12 × 130 ft. is in use at the Blue Island yards, and last year a standpipe 25 × 60 ft. was built at Geneseo, Ill. This latter is built on a concrete foundation with a 6-in. inlet pipe and 12-in. outlet pipe built into the concrete. The outlet pipe leads to two 10-in. pipes and water columns of the same size. As soon as the weather will permit, the erection will be commenced of a standpipe 20 × 60 ft. at Wilton, Ia., and one 30 × 30 ft., at Bureau, Ill. The latter will be on a hill 40 ft. high, giving a head of about 70 ft. at the level of the track. The 12-in. outlet pipe will connect with two 10-in. pipes leading to 10-in. water columns. There has been no trouble from freezing of the water, though a 6-in. crust of ice sometimes forms inside the shell of the standpipe. All these standpipes were built by the Chicago Bridge & Iron Co., of Washington Heights, Chicago. As to cost and efficiency, Mr. W. K. McFarlin, Superintendent of Maintenance and Construction (lines east of the Missouri River), informs us that the standpipes are cheaper than wooden tanks of equal capacity supported on trestles, and that he considers it better and cheaper to support the water on water instead of on iron columns.

Cupped Firebox Sheets.—As the result of experiment, Mr. Wilson, the Superintendent of Motive Power, has adopted cupped plates as the standard for fireboxes, and about 45 engines now have fireboxes of this pattern. The advantages claimed are a marked increase in the life of plates and staybolts, with a reduction in cost for repairs and renewals. The heads of the staybolts rest in the cups or depressions, and are thus protected from the direct action of the flames, while the cupping allows the plate to expand and contract with the staybolt, so that leaky staybolts are almost unknown on engines fitted with these fireboxes, even on divisions where bad feed-water is used. The cupping is done by a hydraulic riveting machine, and the holes are then drilled and tapped. The staybolts are first riveted on the inside, a special holding-on tool being then used in riveting up the outside ends. The additional cost is about $3 to $5 per firebox, according to the size, but this is said to be insignificant in comparison with the saving effected by eliminating the continual expense for calking and riveting staybolts in ordinary fireboxes.

COMPARATIVE TESTS OF STEAM INJECTORS.

The Bulletin of the University of Wisconsin for June, 1897, contains a paper by George Henry Trautmann, B. S., describing a series of tests of the performance of steam injectors. The work was done under the supervision of Prof. Storm Bull, who vouches for its accuracy. The injectors were tested at different temperatures of feed water and different steam pressures, and records were made of the corresponding delivery pressures and temperatures and of the number of pounds of water delivered per pound of steam used. We have condensed the principal results in the tables given below

Highest Delivery Temperatures Corresponding to Given Temperatures of Feed Water.

Feed temperature, degrees.			Delivery temperature, degrees.
50	8	injectors,	133 to 180
80	8	"	162 " 209
100	6	"	170 " 222
120	4	"	206 " 231

Highest Delivery Pressures Corresponding to Different Feed Water Temperatures.

Feed water temperature.	Boiler pressure—Delivery pressures, ——lbs. (range of 9 injectors.)—— 40 lbs.	60 lbs.	80 lbs.
120	45 to 64	68 to 90	90 to 115
110	47 " 68	70 " 100	90 " 123
90	47 " 72	77 " 108	98 " 134
70	47 " 76	82 " 110	103 " 140
50	45 " 82	83 " 114	107 " 140

Performance of Different Injectors.

Name	Lbs. water per lb. steam.*	Lowest pressures under which injector will work, Feed, 50°.	Feed, 90°.	Feed, 110°.	Limit of feed temp. degs.
Monitor	10.36 to 13.19	..	22	..	102
Sellers	10.98 " 16.17	..	25	10	125
Penberthy	10.50 " 12.31	38	35	..	94
Metropolitan	9.37 " 11.13	4	4	5	118
Korting	9.11 " 9.78	3¹	3¹	3¹	130
World	8.62 " 9.31	3¹	3¹	3¹	130
Excelsior	7.57 " 8.20	8	..	..	87
Sherwood	7.50 " 8.68	12	..	9	122
United States	9.59 " 9.78	40²	..	..	..

* The figures are the results obtained for the whole range of feed water temperatures and of steam pressures.
¹ Or lower. ² Feed 70°.

Operation of Injectors with Feed Water at 50°.

Name.	Size of steam pipe, ins.	Gallons per hour.	Average water per lb. steam.	Temp. of delivery, degs.	Lim. of suction ins. of mercury.
Sellers	1¼	615	12.17	137	20.5
Sherwood	1	579	7,83	179	21.25
Metropolitan	1	645	11.07	144	17.75
Monitor	1	511	12.37	175	12.5
Korting	1¼	508	9.47	159	18.5
Penberthy	¾	478	12.03	137	16.5
World	¾	370	9.22	160	19.5
Excelsior	¾	286	7.95	175	14.25

AN AMATEUR MODEL-MAKING COMPETITION will be one of the features of the Electrical Exhibition to be held in New York city May 2 to 31. The matter is in the hands of a committee consisting of Prof. Morris Loeb, Dr. C. A. Doremus, Dr. W. E. Geyer, and Mr. T. C. Martin. Printed forms giving rules and regulations for the competition can be had from the management, 15 Cortlandt St. The classes will be awarded prizes not to exceed $50 and bronze medals, the exhibits to be judged by a committee of five well-known men. It is believed that the contest will awaken general interest and elicit some interesting apparatus, as there are a great many young people and students in and around New York who find pleasure in handiwork of this character. The classes are as follows:

Class A.—Working model or actual machine of a dynamo-electric or electro-dynamic type; made by one or more boys under 21, so far as designing, lathe work, assembling and finishing is concerned. Class B.—Instrument of precision, made by amateur or student, including galvanometers, resistance bridges, etc., etc. Class C.—Practical application of electricity to communication, the assembling and finishing to have been the work of a single exhibitor. Class D.—Ingenious application of electrical appliances to domestic, etc., uses by amateurs under 18; none of the apparatus to be necessarily of home manufacture. Class E.—Design or working drawing of an electrical appliance or installation, made within the past twelve-month by a student of a recognized chartered institution, and bearing the instructor's certificate as to its bona fides. Class F.—Design or instrument made by a teacher, below the grade of college professor, for illustrating some electrical law.

All models submitted must be received at least one week previous to the opening of the Exhibition.

A UNITED STATES, HAWAIIAN, JAPAN AND CHINA telegraphic cable line is the purport of a bill favorably reported upon by the House Committee on Interstate and Foreign Commerce. The bill calls for an annual subsidy of $100,000 for 20 years; in return for which the government would have right of way over the cable free of cost for messages. The Pacific Cable Co., of New York, is organized to lay the cable, which should be finished between San Francisco and Hawaii by Jan. 1, 1900, and connect with China by July 1, 1901.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 28. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

We wish to throw out as a suggestion to all interested in good roads that stronger efforts should be made to keep roads in repair after they have been improved. A number of states have adopted laws under which roads are improved partially at the expense and partially or wholly under the supervision of the state. One of the great objects of this action is to establish stretches of model roads throughout the country which shall stimulate local governing bodies to build roads on the same principle. In some sections of the country, at least, there is as much need of instruction in road repair methods as in road construction. Might it not be well for the states, if they are to aid in road improvement, to devote some of their money to examples of how roads once improved should be kept in repair?

In our issue of Dec. 30, we discussed the question whether in the proposed New York Rapid Transit railway tunnel, fog would constitute the same obstacle to the movement of trains that it does on the surface—a question which had also been ventilated to some extent in the columns of our contemporaries. We quoted at that time the experience in the movement of cars in the sections of the Boston subway which have been opened to traffic as evidence that no fog would be present in the tunnel, even though it were thick in the streets above. It appeared to us that this was sufficient to settle the question definitely as to what might be expected in the similar tunnel in New York, if it should be built. One of our correspondents, however, calls our attention to an electric underground railway close to the street surface which had been in operation longer even than the Boston subway. We refer to the underground railway in Budapest, Hungary, which was described and illustrated in our issue of March 21, 1895. It seemed worth while to learn the experience on this road with reference to the presence of fog in the tunnel, and through the courtesy of Mr. Fr. von Emperger, of Vienna, and of Chief Engineer Hochenegg, of the well-known firm of Siemens & Halske, we have been able to obtain information direct from Herr Worner, General Manager of the Budapest railway. His letter is as follows:

To Engineer Fr. von Emperger,
Vienna, Hotel Erzherzog Karl:

In accordance with the request of Chief Engineer Hochenegg, I beg leave to state that no fog has been observed in the tunnel of the Fr. Joseph's Underground Railway at Budapest even when fog prevailed on the surface. The absence of fog is especially noticeable on entering the underground stations, when the weather outside is foggy. No fog has ever been observed at the stations. The signal lamps in the tunnel are visible at the same distance on foggy days as on clear days, which is good evidence that no fog is present in the tunnel.

It may be of interest to state that the air in the tunnel is very dry. The ballast on the tracks dries out so completely that the line has to be sprinkled at intervals to maintain a secure bedding of the track. The complete exclusion of the ground water and surface drainage from the tunnel is effected by the asphalt felt lining of the concrete walls.

Trusting this may answer satisfactorily the queries submitted to you by the editor of the Engineering News,

Your obedient servant,
Worner.

Budapest, Feb. 18, 1898.

In the light of the experience in Boston and Budapest, we think it will now be accepted that freedom from fog is a legitimate argument in favor of tunnel routes for rapid transit railways in cities.

THE HISTORY OF THE SHAFT GOVERNOR.

During a meeting of a small group of engineers in New York city a few months ago, at which a member of the staff of this journal was present, the conversation turned to the subject of steam engine governors. Mr. Charles T. Porter, the veteran engineer, well known as the inventor of the Porter fly-ball governor, with central counterpoise, and as one of the inventors of the Porter-Allen engine, was one of the party, and the question was asked of him: "Who was the first inventor of the shaft governor, now commonly used in high speed engines?" "Well, I think I was," was his reply. He proceeded to relate that he had patented a governor in 1861, in which two weights revolved around a horizontal shaft, their centrifugal force being resisted by a spring which is under strong initial stress, and had successfully applied it in that year on the Atlantic steamer "New York," of the North German Lloyd line. The governor was used to close the throttle valve when the engine raced. It had the fundamental elements of the shaft governors of the present day, viz.: the horizontal shaft, the weights revolving around it, and the spring in initial tension when the engine is at rest, but it was not applied, as is the modern shaft governor to shift the eccentric of the engine and thus to vary the point of cut-off. Mr. Porter was not able to say who was the first to apply this form of governor to change the throw of an eccentric, or to rotate the eccentric so as to change its angular advance.

As the history of the shaft governor is somewhat obscure, we have been led to institute a partial investigation of the subject, while many of the men who assisted in the development of the governor are still living.

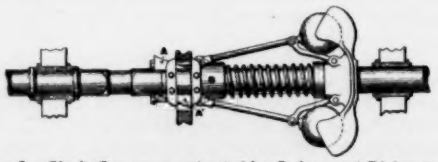


Fig. 2.—Shaft Governor patented by Robey and Richardson in 1869.
From Proc. Inst. M. E. CXX. Plate 3, Fig. 12.

It appears that before 1861 governors had been patented, in which there were springs applied to counteract the centrifugal force of revolving balls. Two governors patented by T. Silver, U. S. Pats., 13,202, July 3, 1855, and 23,790, April 26, 1859, are instances, but neither one of these governors came into practical use. Mr. Porter's governor was apparently the first which had the essential requirements of a practical shaft governor, and it was also the first shaft governor which was put into practical operation. It was used, however, to move a throttle valve, and not to shift an eccentric.

Mr. Porter has sent us the original of his patent, No. 32,583, June 18, 1861, and also a circular dated Nov., 1861, advertising the governor and containing testimonials concerning its successful working from the Chief Engineer and the Master of the steamship "New York," dated May 30, 1861. The accompanying illustration, Fig. 1, is reproduced from one of the two given in the circular. It is explained in the circular that the novel feature of the governor and the one which gives to it its value, is the initial compression of the spring. The compression is such that if the radius in which the balls revolve increases from 10 ins. to 15 ins., or 50%, 50% will also be added to the original compression of the spring, increasing it from 2 ins. to 3 ins. The power required to give the additional compression to the spring is obtained from the enlargement of the circle described by the balls, without any increase in the number of revolutions, centrifugal force varying directly as the radius of the circle. The following extract from Mr. Porter's patent shows clearly the scope of the invention:

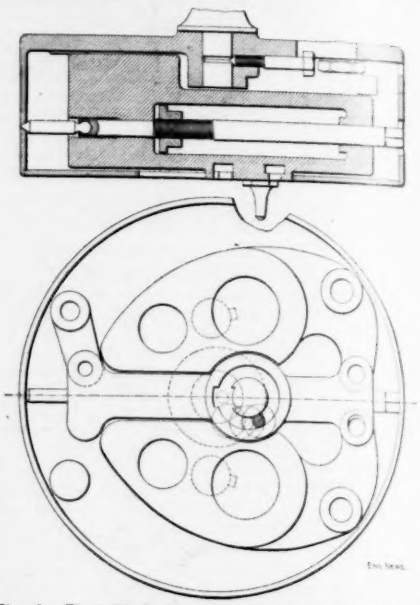


Fig. 3.—First Shaft Governor Used by the Buckeye Engine Co.
From a Drawing dated Feb. 15, 1872.

This invention relates to the employment of the resistance of a spring as a counterpoise to the centrifugal force of the balls and arms of a centrifugal governor, by means of which such governor is made capable of working in a horizontal position and hence suitable for marine engines. The improvement consists in so applying and combining the balls and arms, and the spring, that in all positions of the balls and arms the distance through which the spring is deflected shall bear a nearly constant ratio to the radius of the circle described by the center of gyration of the balls and arms, thereby making the governor extremely sensitive to the slightest variation in the speed of the engine.

Claim: Giving to the spring of a centrifugal governor an initial deflection of such amount that, in every position of the balls, the radius of the circle described by them and the distance through which the spring is deflected shall bear a nearly constant ratio with each other, when constructed and operating in the manner and for the purposes herein shown and described.

It is commonly believed among engineers in this country that the first application of a shaft governor to moving the eccentric of an engine was made by the late John C. Hoadley, of Lawrence, Mass., in the engine built by him in 1872-3, the governor of which was patented by him Oct. 28, 1873, No. 144,098. We think it must be allowed, however, that Mr. Hoadley was anticipated in the broader features of the modern shaft governor by the British patent of Robert Robey and John Richardson, No. 2,463, Dec. 1, 1869, leaving to Mr. Hoadley only the claim for priority in the particular details of construction he used, which differ considerably from those of Robey and Richardson, but are not, as we understand them, essential features of the modern shaft governor.

We quote the following extracts from Robey and Richardson's specification:

We mount the governor on the crank shaft of the engine and connect it with the eccentric which regulates the admission of steam to the cylinder in such manner that the governor may act to vary either the throw or the angular lead of the eccentric. • • •

A rectangular slot is cut in the eccentric parallel with the line connecting its two centers of forward and backward motion. This slot fits on the square part of the crank shaft upon which the eccentric slides at right angles to the crank. Two wedges are fitted in the slot and connected with the governor slide; as the slide is drawn along the crank shaft by the centrifugal motion of the

governor one wedge is drawn back and one forward through the slot in the eccentric by which means the travel of the valve is reduced, the cut-off is made earlier while the lead remains constant. • • •

When two valves are used, one for steam and exhaust and one for cut-off only, we regulate the cut-off by altering the angle of the valve eccentric with the crank. This is done by cutting a slot spirally in its boss which fits a pin which is fixed in a collar which slides over the boss. When this collar is drawn out parallel with the axis of the shaft by the governor the eccentric is caused to advance its angle and thus cut off earlier.

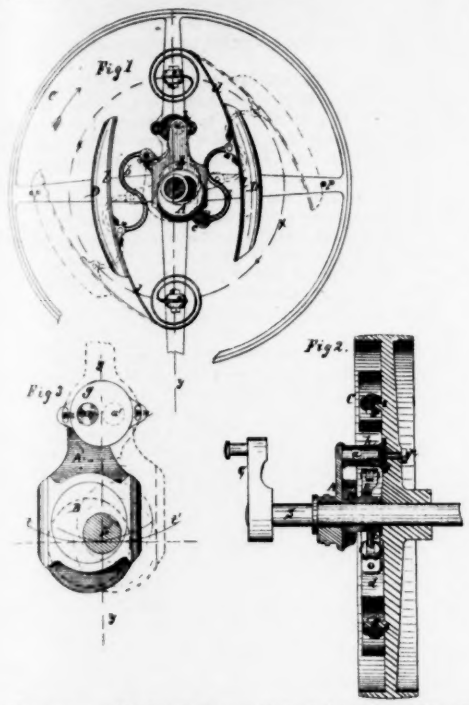


Fig. 5—Steam Engine Governor Patented by D. A. Woodbury, Sept. 27, 1870. No. 107,746.

In a paper by Mr. John Richardson in "Proceedings of the Institution of Civil Engineers," Vol. CXX., 1895, p. 216, entitled, 'The Regulation of Steam Engines," he describes and illustrates the governor, which he says was made by him in 1869. We reproduce the illustration in Fig. 2 herewith. Its similarity to the Porter shaft governor is very close, the difference being that it moves an eccentric instead of a throttle valve. It is described as follows:

In this case a governor of the spring type is used in connection with an adjustable eccentric. The object to be attained is to move the center of the eccentric in a straight line at right angles to the crank, thus maintaining a constant lead while varying the travel and the point of cut-off. This is accomplished by a pair of wedges A A, moving in the same direction and connected to a moving slide B.

It will be seen that Robey and Richardson invented the application of the shaft governor of Chas. T. Porter, both to shifting the eccentric across the shaft without changing the lead of the valve, and to rotating it around the shaft, so as to change the lead. Mr. Hoadley invented a particular form of shaft governor, and he is entitled to the credit of being one of the first to build an engine with a shaft governor in the United States, his claim to actual priority being disputed by the Buckeye Engine Co., of Salem, O.

Mr. Gardiner C. Sims, of the Armington & Sims Engine Co., was, in 1872, engaged as draftsman and designer by Mr. Hoadley. In a recent letter to Prof. F. R. Hutton, of Columbia University, Secretary of the American Society of Mechanical Engineers, from which we have been allowed to quote, he gives some interesting facts concerning the origin of Hoadley's engine, taken from memoranda made at the time, from which we quote the following:

I accepted, • • • arriving in Lawrence Thursday, March 14, 1872, commencing work the following morning by designing a balanced piston valve cylinder, 14 ins. diameter, 20 ins. stroke, together with locomotive boiler for the same. My drawings, at the request of Zerah Colburn, were illustrated in London "Engineering." Mr. Hoadley writing the article. This relates to the automatic cut-off Centennial engine.

April 11, 1872, Mr. Hoadley and family started for San Francisco. April 1, 1872, I commenced to design a 7 × 10-in. piston valve engine, and although it was to have a Judson ball governor, the matter of automatic cut-off had been previously discussed by Mr. Hoadley and myself. During his absence I received several letters, a portion of each mentioning the automatic cut-off, and at last I was instructed to abandon the throttling governor and apply the automatic cut-off, the original sketch having been made on my desk by Mr. Hoadley. Mr. Hoadley and family returned July 5, 1872. As the shaft governor was an entirely new feature, and without precedent, my work was indeed very slow, and we abandoned the original design, as sketched by him, for that of application filed Aug. 1, 1873, patent No 144,098, granted Oct. 28, 1873. I am unable to find my private record of events during the months that followed, yet April 1, 1873, we started the 7 × 10-in. engine, and it was a perfect success. We then tested it for many days, and April 16 I gave it a 5-hour run, showing 14.5 I.HP. with a consumption of 3.6 lbs. of combustible per HP. per hour, with an evaporation of 8.97 lbs. of water per lb. of combustible.

Mr. Hoadley's engine was exhibited at the Centennial exhibition in 1876, and is now in the possession of the Mechanical Laboratories of Columbia University, in New York city. While Mr. Hoadley was at work on his first automatic engine, or in 1872, the Buckeye Engine Co. began work in the same line, Mr. J. W. Thompson, of that company, securing patents for certain forms of shaft governor. The first shaft governor engine exhibited by the Buckeye Engine Co., was a 12 × 20-in., at the Cincinnati Industrial Exhibition in 1875. In it the governor operated to rotate the eccentric around the shaft. Prof. John E. Sweet built his "Straight-line" engine, in which the governor moved the eccentric across the shaft, about the same time, and immediately after, 1876, the rapid introduction of this form of engine began, which has continued to the present time.

Concerning the early history of the shaft governor used on the Buckeye engine, the Buckeye Engine Co. writes us as follows:

We send you a print made from an old drawing in our possession which illustrates the first shaft governor which was used in our experience. It was applied to a separate vertical shaft driven from the engine shaft, but operated the cut-off valve situated above a contracted steam chest in which the main valve of the engine operated. You will observe that the adjustable movement of the driving pin is in approximately a straight line in a direction across the shaft, the line of movement being obtained by linked parallel movement. The pin is also adjustable in a circular slot.

The spring not shown in the drawing surrounds the stud seen in sectional view which passes across the axis of the shaft and is adjustable from the periphery of the wheel. Note also the "Schiele" curve used in the shaft bearing, as well as on the eccentric pivot. This governor is said to have operated finely and was used on an engine sold to Brown & Co. in a flouring mill at Youngstown, Ohio, as well as on other engines following. The engine was ordered from this company on March 29, 1872, and shipped on Sept. 7, 1872, between which dates the governor was developed by our Mr. J. W. Thompson. It was the forerunner of the shaft governor which was used on our automatic engines.

On further investigation we find that the first automatic governor mounted directly on the engine shaft and operating to move the cut-off eccentric about the shaft, in exactly the way in which we now govern, was applied to a 10 × 18-in. engine built for Jacob Hatton, of Millersburg, Iowa, which engine was ordered from us on Oct. 11, 1873, and shipped on Dec. 18, 1873.

We enclose a print showing some of the details of this governor, which is the only drawing of the governor that we are able to find. The governor exhibited at the Cincinnati Exposition in 1875 was made the same as this.

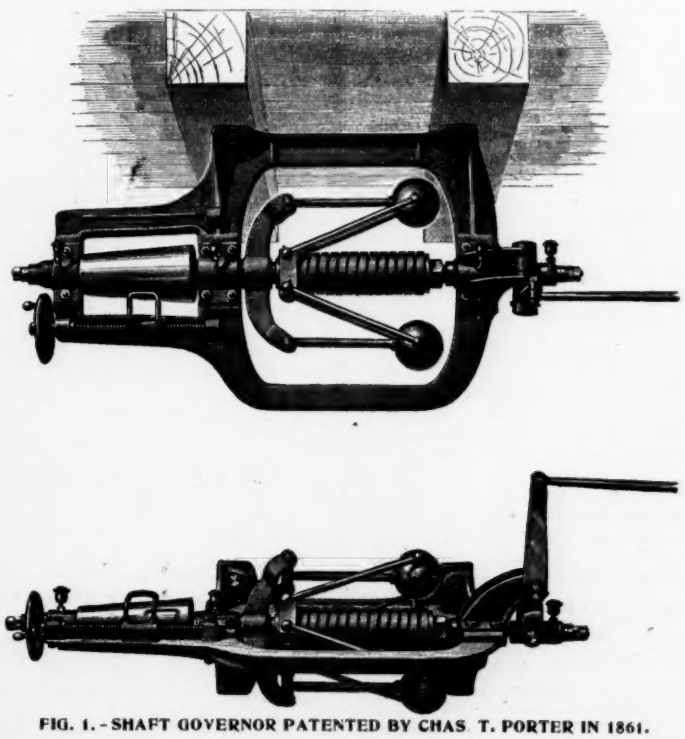


FIG. 1.—SHAFT GOVERNOR PATENTED BY CHAS. T. PORTER IN 1861.

We have reproduced the prints referred to above in Figs. 3 and 4. Prof. Sweet calls our attention to the U. S. Patent of D. A. Woodbury, No. 107,746, Sept. 27, 1870, the cuts of which we give in reduced form herewith, Fig. 5. It does not appear that this governor was ever brought into practical use. It embodied the combination of inertia with centrifugal force, as does Prof. Sweet's governor.

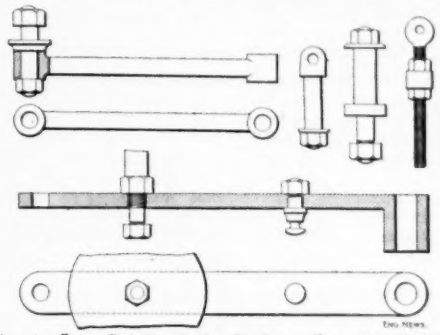


Fig. 4.—Some Details of the Buckeye Governor of 1873.

Mr. Hoadley's invention of 1872 appears to have been anticipated not only by Robey and Richardson in 1869, but by Hartnell and Guthrie in 1872. "Engineering," of July 19, 1872, describes a portable engine exhibited at the Cardiff Show by Messrs. E. R. & F. Turner, and states that its construction introduces the patents of Messrs. Hartnell and Guthrie for the system of framing and the governor. It says:

The eccentric is acted on by the governor which is enclosed in a drum 18 ins. diameter, placed on one side of it on the crank shaft. The center of the eccentric traverses, in an arc of 8½ ins. radius, from the point of full gear (either forward or backward) to that of mid gear, the expansive action being much the same as with the link motion.

"Engineering," of Dec. 13, 1872, describes the governor. It says:

There are two governor weights, each pivoted at the end, placed at opposite sides of the shaft and coupled so as to balance each other. The weights are pressed towards the shaft by springs which yield to the centrifugal force when the engine attains the proper speed, the weights opening and closing as the speed varies. The eccentric is detached from the shaft and swivels freely on a pin near the outside of the governor case. The weights move the eccentrics by means of a kind of scroll motion which also enables them to hold it fast.

Mr. Wilson Hartnell also describes this governor in Proceedings of the Institute of Mechanical Engineers, Aug., 1882, p. 408, and says of it:

This form of governor was first used at the Cardiff engine trials ten years ago, and was immediately adopted by Messrs. E. R. & F. Turner for their 8-HP. portable engines; from that time uninterruptedly till now the throttle valve has been abolished in their 8-HP. engines.

If Richardson's governor of 1869 was defective on account of the friction of the wedges used in it, as it appears it must have been, Hartnell and Guthrie's governor seems to have avoided its defects, and the evidence seems to be that they anticipated Mr. Hoadley by about a year, both in patenting a practical form of the governor, and in introducing it into use. All of these governors, however, are subordinate to Mr. Porter's invention of 1861, and he must be held, therefore, to be the first inventor of a practically operating shaft governor.

THE SUBMARINE TORPEDO-BOAT "HOLLAND" had another trial on March 11, and remained 14 ft. under water for 30 minutes. An open trial in deep water is now to follow at once.

LETTERS TO THE EDITOR.

A Strongly-Built Snow Plow.

Sir: You may be interested in knowing that one of the locomotives in the wreck at Hospital station, on Jan. 31, illustrated in your issue of Feb. 24, was pushing a snow plow at the time of the collision. This is a probable explanation of the puzzle alluded to as to how this locomotive got on top of the other with so little damage.

Yours very truly, Dorsey Ash.

Northboro, Mass., Feb. 24, 1898.

Statistics of Engineering Schools.

Sir: The statement, on p. 143, of your paper for March 3, in regard to engineering students in attendance at the University of Michigan for the year 1896-7 is inaccurate. There were, in that year, 5 resident graduates, 3 graduates studying in absentia, and 276 undergraduates. As our first-year students all have the same studies, they are desired to postpone the choice of civil, mechanical or electrical engineering until the second year. The compiler of the statistics above referred to has, therefore, probably omitted the 100 students who entered in 1896.

Respectfully yours, Chas. E. Greene.

University of Michigan, Ann Arbor, Mich., Mar. 7, 1898.

County Surveyors and Surveyors-General.

Sir: My attention has been called to some statements made in the article entitled "County Surveyors and Surveyors-General," by Professor Von Ornum, in your issue of March 3, 1898. While I heartily agree with the gentleman in question, and also with the editorial of your able journal on the present lamentable practice of putting technical work under the supervision of political appointees and men of no scientific training, I wish to correct the idea that the Surveyors-General of Minnesota are scalers of logs; or that the Surveyor-General of Nevada is elected and has a salary of $1,000 per year, or that the salary of the Surveyor-General of California is $6,000 per annum.

In explanation of the above I would state, that the Surveyors-General of Alaska, Arizona, California, Colorado, Florida, Idaho, Louisiana, Minnesota, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming, are appointed by the President of the United States for a period of four years. The compensation is everywhere $2,000 per annum, except Florida, Louisiana, Minnesota and Nevada, where it is $1,800 per annum.

The duties of the Surveyors-General consist of the supervision of all the public surveys, both land and mineral, in their respective states. They report to the Commissioner of the General Land Office under whose jurisdiction the routine work of these different state offices are conducted and where final action is taken.

Very respectfully, T. R. Hinsdale,

Division of Public Surveys, General Land Office.

Washington, D. C., March 7, 1898.

Cost of Concrete in the United States.

Sir: In your issue of March 3, Mr. Wm. M. Hall states that in the work on Rough River, Ky., concrete was made at a cost, for cement, of $4.56 per cu. yd. of concrete. The cost of cement per bbl., on the work he states was $3.15. This would be equivalent to about 1.45 bbls. of cement per cu. yd. of concrete.

As it is a very important point, in close estimates, to know how much cement will be required per cu. yd. of various kinds of masonry, I am sure it would be a matter of general interest, to give the specifications under which this concrete was made, and the details of the manner in which the work was executed. Respectfully, E. S. G.

Yonkers, N. Y., Mar. 4, 1898.

(The following is taken from the Report of the Chief Engineer of the United States Army for 1896, Part IV., pp. 2283. It is a portion of the report submitted by Mr. Wm. H. Hall, Assistant Engineer, and is dated June 30, 1896.—Ed.)

The heart of the concrete wall was made of a mixture of 1 part German Portland cement, 2 parts Ohio River washed sand, 2 parts of washed gravel and 3 parts of Green River limestone which passed through a screen with 2-in. meshes and was cleaned of all dust or other pulverized matter. The exposed faces of the river wall were composed of a 6 in. layer of mortar made out of 1 part of cement to 2 parts of sand. The top of the lock wall was finished with about 3 ins. of this facing, and the top of the abutment with a mixture of 1 part cement, 2 parts sand and 3 parts gravel. . . . All materials for concrete were of very excellent quality. . . . In determining the proportions of ingredients for concrete careful experiments were made to determine the voids in sand and in various mixtures of the aggregate. . . . The experiments for fineness gave the following:

Held by No. 20 sieve	11%
Passed No. 20 sieve, but held by No. 30	14%
" 30 " " " 50	53%
" 50 "	22%

The voids in the sand averaged 31% of the volume. The aggregate composed of gravel and broken stone averaged as follows:

	Stone.	Gravel.	Voids.		Stone.	Gravel.	Voids.
A	100%	..	48%	D	60%	40%	38.5%
B	80%	20%	44%	E	50%	50%	36 %
C	70%	30%	41%	F	..	100%	35 %

The shrinkage obtained by making the mixtures were:

B	5.5%	D	8.6%
C	6.5%	E	9.7%

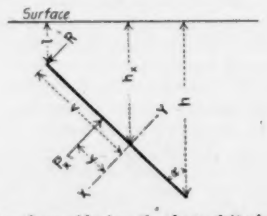
The ingredients of concrete measured separately were for one batch of about 1 cu. yd.: 4.7 cu. ft. cement, 9.5 cu. ft. sand, 9.5 cu. ft. gravel, 14.1 cu. ft. stone, and from 2.21 cu. ft. (16½ gallons) to 2.74 cu. ft. (20½ gallons) of water. The above are the extreme quantities of water used. The amount of water used was governed by the absorption of the ingredients and as that could not be made uniform, the measure of water for concrete was varied from hour to hour, as the condition of the concrete being rammed in place indicated.

In all, 2,059 bbls. of cement at $3.36⅛ and 900 bbls. at $3.00½, were used, or an average of $3.18½ per bbl. Also,

830.7 cu. yds.	broken stone at	$2.22
576.5 " "	gravel at	1.39
670.2 " "	sand at	1.22

Bending Moment on Beam Subjected to Water Pressure.

Sir: I recently had occasion to find the maximum bending moment in an inclined beam, resisting water pressure, the upper end of the beam being below the surface of the water. Such is the case in a Parker bear trap dam when the surface of the water used to produce the internal pressure is at a higher elevation than the crest of the dam, when elevated. It also frequently is required in the computation of the stress in penstock walls, etc., for water wheel chambers. Being unable to find the desired equation in any of the text books relating



to the subject and considering the fact of its being tedious to derive, owing to the lengthy equations resulting, it may be of interest to your readers:

Let h = the head in feet on the lower end of the beam.

l = " " " " upper " "

R = the reaction at the upper end of the beam, due to the pressure on entire length of it.

α = the angle of inclination of the beam from the vertical.

h_x = the head on the beam at any plane of section, as X Y.

P_x = the pressure on the beam above the plane of section, as X Y, and let it be considered to be concentrated at the center of pressure.

y = the distance of P_x from X Y.

v = the distance of R from X Y.

w = the weight of a cu. ft. of water.

Considering a beam of unit width, one foot, the bending moment at any section, as X Y, will be:

$$M = R\,v - P_x\,y \quad \ldots\ldots(1)$$

$$\text{But } R = \frac{w \sec \alpha}{6}\left[h^2 + h\,l - 2\,l^2\right]$$

$$v = (h_x - l)\sec\alpha$$

$$P_x = \frac{W}{2}\sec\alpha\left[h_x^2 - l^2\right]$$

$$y = \sec\alpha\left[h_x - \frac{2}{3}\left(\frac{h_x^3 - l^3}{h_x^2 - l^2}\right)\right]$$

Substituting these equations in eq. (1) and reducing, there results for the general equation, for the bending moment:

$$M = \frac{W}{6}\sec^2\alpha\left[(h^2 + h\,l + l^2)\,h_x - h_x^3 - h\,l\,(h + l)\right] \quad \ldots\ldots(2)$$

Finding the first derivative of M with respect to h_x in eq. (2) we find it to be a maximum when

$$h_x = \left(\frac{h^2 + h\,l + l^2}{3}\right)^{\frac{1}{2}} \quad \ldots\ldots(3)$$

Substituting the value of h_x, eq. (3), in eq. (2) and reducing, there results for the maximum bending moment

$$M\,\text{max} = \frac{W}{6}\sec^2\alpha\left[2\left(\frac{h^2 + h\,l + l^2}{3}\right)^{\frac{3}{2}} - h\,l\,(h + l)\right] \quad \ldots\ldots(4)$$

If now, α and l both reduce to zero, we have the case of a vertical beam with its upper end at the surface of the water, and eq. (4) reduces to

$$M'_{\text{max}} = \frac{w\,h^3}{3^{\frac{3}{2}}} \quad \ldots\ldots(5)$$

Substituting the value of w = 62½ lbs., in eq. (5), we get the convenient form

$$M'\,\text{max} = 4.009\ h^3 \text{ foot lbs.,}$$

or (practically) $= 48\ h^3$ inch lbs.

Respectfully,

James W. Rickey, C. E.

Minneapolis, Minn., March 1, 1898.

Engineering Notes.

Sir: Nowhere else in the Central States has the manufacturing industry so nearly reached the development characteristic of New England as in Southwestern Ohio, from Cincinnati to Dayton. Dayton, which is justly the "Gem City" of Ohio, is a place of much interest to the engineer, on account of its splendid paved streets, its modern residences, and its fine public buildings. Numerous improvements are contemplated, and Mr. F. M. Turner, the City Engineer, with a number of assistants, was found busy with plans for next season's paving and sewer work and a number of bridges which are contemplated.

The works of the Barney & Smith Car Co., which are among the largest in the country, were found to have plenty of orders ahead, but to be delayed somewhat by lack of material. The recent development of interurban electric railways has caused them to go into electric car work extensively, and some fine cars for the Columbia & Maryland Ry., the new road between Washington and Baltimore, were seen ready for shipment.

An elegant vestibule train for the Chicago & Northwestern Ry. was also in process of construction. Much of the interior work was of inlaid designs and everything promises to be of the finest.

These shops were formerly operated from shafting run by steam power, but an electric plant has been in use for some time, and motors are now used to operate the different machines, a measure of great economy where the plant is composed of so many separate buildings.

There are numerous other very large factories here of much interest to the engineer, but none which will so well repay a "week's" study as the great plant of the National Cash Register Works. The chief interest of these works lies in their solution of the labor question, under the president and vice-president of the company, Messrs. J. H. and F. J. Patterson. In fact the method adopted is known as the "Dayton plan."

Every engineer engaged with a manufacturing concern or in charge of one has doubtless, at some time or other, been called upon for help in allaying some labor trouble. A number of years ago the company referred to above was found to be losing money at the rate of nearly $1,000 per day, and the officials of the company went into the factory and literally took off their coats in an endeavor to learn what was the matter. They found the employees to have no interest in the business, endeavoring to do as little work as possible, at war with the superintendent and dissatisfied with their surroundings generally.

The office of superintendent was abolished, and the management of the factory put into the charge of committees of the employees and officers, a truly federal plan of government. The general business of the concern is in the hands of a committee of ten officers of the company, which is termed the Executive Committee. The selling is in general charge of a committee of eight district managers, who meet at the factory every 60 to 90 days.

The Office Committee has charge of office affairs, while the Factory Committee, composed of the heads of the departments, meets once a day for consultation, the members alternating as chairman for a month each. Prizes are offered for complaints and suggestions from employees, and meetings of the entire force are held to consider suggestions and improvements. Each year a convention of the agents is held, and the factory people meet them to learn what is wanted to keep up sales.

The Advance Club meets once a week in a hall in the factory to consider suggestions and discuss questions of interest. This club is composed of the Officers, Factory Committee, heads of office departments, all foremen, sub-foremen and 25 employees selected by the foremen each week. Free lectures are also given the employees during the winter on practical and scientific subjects.

Monitor boards are shown in various parts of the factory, giving the standing of the various departments in proficiency.

There is no general scheme of profit sharing, and the company attributes its success to five things: (1) Meetings of employees; (2) promotion from the ranks; (3) individual responsibility; (4) liberal salaries, and (5) quick decisions.

The grounds about the factory were laid out by Frederick Olmsted, the well-known landscape architect, and everything made attractive. The color in use on the outside and interior of the buildings and on machinery is a soft yellow. Palms are placed about the factory among the machinery, and everything kept neat and clean by a force of 30 uniformed janitors.

The new four-story building, 50×350 ft., is of slow burning construction, and is very well lighted; the main building, 60×350 ft., is also well provided with windows. The power is supplied from a central station by a 300-HP. tandem compound condensing Buckeye engine, directly connected to a Siemens-Halske generator of about 285 HP. The 2,500 incandescent lamps and 78 arc lamps are operated by a separate engine and dynamo. Motors are placed about the factory at numerous points to operate the various departments.

The work about the factory is all kept track of by a

system of color cards. In the stock rooms is a monitor board bearing a card for each kind of stock carried. On each card is a disk of five colors, and if red is displayed the stock is exhausted; if yellow, less than a month's supply is on hand, but if white, the stock is all right.

There is a special department for the making of all tools, such as punches and dies, which are used about the works. Four experimental departments are also kept up, each one in charge of a skilled inventor, and new inventions are constantly being patented; not only as improvements on their own machines, but on those of competitors.

The patterns for the ornamental brass castings are made from metal by a force of men, much of whose work is finer than the handwork of a jeweler. These patterns are molded and cast in a light, airy and clean foundry building, which reminds one but little of the proverbial foundry.

Building work is brisk in Detroit, Mich.; the new steel skeleton of the Buhl Building is completed and the floors are being laid of "slow burning" construction—2×6-in. and 2×8-in. pine plank, laid close on edge. In view of the recent fire, it is a surprise that some of the many simple and effective forms of fireproof floors have not been used.

SWING BRIDGE ACROSS THE BLACK RIVER AT PORT HURON, ONT., GRAND TRUNK RY.
Built in 1859 by the Regents Canal Iron Works, England.

The new Detroit Theater building is under way, the steel work being built by the Forest City Wire & Iron Co., of Cleveland, O. The architects of the work are Mason & Rice, with J. M. Wood, of Chicago, as Consulting Theater Architect. The structure will be entirely fireproof, both floors and partitions.

The works of the Detroit Bridge & Iron Co. were in full operation, the work for the new Victoria Bridge at Montreal being practically completed. One machine worthy of mention is a pin lathe, which takes two roughing cuts and the finishing cut at one travel of the tool rest, thus making quick work of large bridge pins.

The shops are thoroughly equipped with air hoists, and a large compound Ingersoll compressor has been installed to supply compressed air for them. An electric crane has also been added for handling heavy pieces. The work is transferred from one building to another by using an ex-Manhattan Elevated Ry. engine for switching.

The Detroit Dry Dock Co. have just made a successful launch of the big sidewheel steamer "City of Erie," which they are building for the Cleveland & Buffalo Transit Co. It is 324 ft. long and 78 ft. beam, with modern machinery, fine equipment and accommodations for 450 passengers.

The service of the Grand Trunk Ry. to Port Huron, where the connection is made with the main line, is excellent, both in equipment and time. The station is now located near the tunnel and quite a distance from the city, the tunnel being the principal stopping place on account of changing engines. Approaching the tunnel on foot, one is amazed at the great cut which was made for the approach, and which resembles a great ship canal minus the water. The slopes are carefully drained, and some attempt has been made to cover them with sod by seeding. The bottom of the slope is protected by a low stone wall, and near the entrance or portal is a pump house, where four Worthington pumps are located for pumping the water from the slopes to the surface and from the tunnel as well. The track is doubled up to the portal, while only a single track is laid through the tunnel.

The masonry of the portal is worthy of a more public place where it could be seen and appreciated. One of the large decapod engines came down the grade at the head of a freight and shot into the tunnel with a roar, making a weird sight. Before it entered the smoke and steam was pouring out, but after the train was all in, such a suction was created as to draw the smoke and steam from the pump house quite a distance away, and had the Japanese arrangement of a curtain been provided it would seem that the tunnel would be cleared of smoke. The ventilating fans, however, do not seem to keep the tunnel entirely free from smoke and gas, as only a few weks ago, on account of a freight train breaking in two and the engine backing in for the other section, three men were killed by suffocation. Masons were at work within concreting or cementing the upper half of the cast-iron lining to prevent corrosion, the lower half having been covered originally. The house over the tunnel, which was bought at the time of building, to allow the cutting of holes through the walls to run survey lines, has settled very appreciably, and the lowered surface of the ground could be seen along the line; this settlement is said to have stopped, however.

Where the old line of the Grand Trunk crosses the Black River there is an iron bridge, constructed in England in 1859 (?) by the Regents Canal Iron Works, of which Henry Grissell was the engineer. The approach spans are plate girders, with 24-in. cover plates in short lengths, but spliced on both sides by plates, the inside one being offset over the flange angles. The stiffeners curve out on the cover plates—English style—and have plates riveted to them at right angles to the girder, making a 12-in. stiffener. The cross frames are of bars. The draw span is a through one, with floor beams and stringers, the girders being of box section with curved top flange. The length is about 122 ft., but to support the span when swinging there is a cast A frame at the center, with rods running to the middle of each half. The cast work of the center and track is heavy enough to support a span of much greater length. The metal work has been kept well painted, and will doubtless last another 50 years at least.

Many improvemnts are under way for the city, and the City Engineer, Mr. F. F. Rogers, was found busy superintending the foundations for two new draw bridges, one at Elm St. and one at 10th St. The steel work on the former is under contract by the Toledo Bridge Co., and on the latter by the Youngstown Bridge Co.

At Saginaw work in engineering was very quiet, but the contracts will soon be let for the Court St. bridge, and during the summer for the new Genesee St. bridge. Quite a departure has been made here from the traditional Michigan cedar block street pavement in the building of a considerable amount of asphalt pavement, and Mr. H. E. Terry, City Engineer, is preparing specifications for paving several more streets.

The sleeping cars on the Flint & Pere Marquette Ry. are owned by the railway company, and for a berth to Detroit it was a complete surprise to pay only one dollar. But this will doubtless be the rule after Gov. Pingree has his innings!

March 2, 1898. E. F. C.

SLOW SAND FILTRATION AT POUGHKEEPSIE, N. Y.

A valuable paper on the filter beds connected with the water supply of Poughkeepsie, N. Y., was read before the New England Water-Works Association, at Boston, on March 8, by Mr. Chas. E. Fowler, Superintendent of the water-works of that city. The paper was full of facts and figures, and with the discussion will soon be published in full in the journal of the Association.*

The plant is a notable one, because of its long history, its designer and the character of the water it treats. It was put in operation in 1872, or more than a quarter of a century ago. It was designed by the late Jas. P. Kirkwood, who was sent to Europe in the sixties by the city of St. Louis for the especial purpose of studying water purification. The water treated is taken from the Hudson River after having received the sewage of Kingston, Hudson, Albany and many towns still further up in the drainage area of the Hudson River. The State Hospital for the Insane discharges its sewage into the river 3,000 ft. above the water-works intake, and 6,100 ft. below the intake is the terminus of the main outlet sewer of Poughkeepsie, the river having a tidal current.

The filtered water is pumped to a reservoir having a capacity sufficient to supply the city about seven days. The size of the filter beds was not increased for nearly twenty-five years, remaining at about two-thirds of an acre in area. In 1896 this area was doubled by the construction of a new bed.

The chief troubles experienced in operating the plant have been clogging by mud, algae growths and freezing. The first would have been far less had it not been necessary to overwork the filters, and the second and third could be entirely obviated by covering the beds. The algae forms like a blanket over the surface of the sand. To remove it the bed must be drained, after which the algae growth dries and can be rolled up like a blanket. No taste or odor has ever been observed to arise from this growth.

The ice has to be removed before the beds can be cleaned. It attains a thickness of 10 to 12 ins., and once was 28 ins. thick. Sometimes the sand will freeze before it can be cleaned.

In cleaning the beds the surface is first loosened by garden forks and rakes, after which it is scraped off in a thin layer. For many years traveling bridges were used in cleaning, being suspended a few inches above the beds and preventing the sand being trampled down by the workmen. As the new bed was built without a dividing wall, a bridge could not be used for it. The timber bridges of the old beds having decayed so they could not be used, new ones were not built, in order that the old and new areas might be operated uniformly.

The sand removed from the beds is replaced at intervals, having been washed previously. Various methods of washing have been tried. In 1881 the sand was washed by running it through two 12-ft. troughs, with a screen between. This cost $2.50 per cu. yd. In 1886 a trough 240 ft. long was installed and the cost of washing was reduced to 61 cts. per cu. yd. In 1892 a hollow tank, with perforated revolving arms driven by a water motor, was introduced, with a valve at the bottom of the tank. The cost by this method was 64 cts. per cu. yd. In 1895-6 the cost was reduced to 54 cts. by a jet washing machine, and in March, 1897, to 27 cts., including water, by a double jet.

The deaths in Poughkeepsie from typhoid fever during the last 18 years, per 10,000 living, have been as follows:

Year.	Deaths.	Year.	Deaths.	Year.	Deaths.
1880	5.9	1886	1.8	1892	5.7
1881	4.9	1887	2.3	1893	9.6
1882	10.6	1888	2.2	1894	6.5
1883	4.5	1889	2.7	1895	4.6
1884	5.2	1890	2.7	1896	2.1
1885	5.1	1891	0.4	1897	4.6

Average for 18 years, 4.72.

In general the death rate has been highest when the efficiency of the beds has been the lowest.

Since December, 1897, both of the beds have been in use, but just prior to that the old bed was renovated, the new one doing all the work. A series of six analyses were made by Dr. S. B. Ward, of Poughkeepsie, in the winter of 1896-7, just after both beds were put in continuous use. They showed an average reduction of 98.56% of the bacteria by the old bed, and 97.52% by the new. The corresponding numbers of bacteria in the applied water averaged about 16,500 per cu. cm.

The new filter bed has an area of 29,640 sq. ft. It has a concrete floor and side walls of rubble masonry, lined with brick. The main drain is sunk below the floor, and is of brick. The lateral drains are of tile, 10¼ ft. c. to c., entering the main drain at right angles. The filtering material consists of 31 ins. of sand on 24 ins. of gravel. The sand and gravel were brought from Long Island on scows. The total cost of the new bed was $28,899, against $62,000 for the old one of the same area, built twenty-five years before. The aver-

*See Eng. News, April 28, 1892, for article by Mr. Fowler describing the original bed and its operations until that date.

age cost of filtration at Poughkeepsie for the past twenty years, not including interest, has been $2.99 per 1,000,000 gallons.

The discussion on this paper was opened by Mr. Allen Hazen, Assoc. M. Am. C. E., of New York city. He said that Mr. Fowler had operated slow sand filters longer and filtered more water than any other man in America. Other cities up and down the Hudson River, without filtration, have had higher typhoid fever death rates than Poughkeepsie. He presented a diagram showing the increase in the area of slow sand filters in this country, Poughkeepsie starting off with less than one acre in 1872, and there now being about nine acres in use and eight more under construction. He wished Mr. Fowler and Mr. Clark would state whether the filtered water at Poughkeepsie and Lawrence, Mass., respectively, had developed tastes and odors upon being stored. Mr. Clark, who is in charge of the Lawrence Experiment Station, said he could not see that filtration had given rise to any increase in the taste or odors of the water. A sponge growth had occurred both before and after filtration was introduced. Last summer this growth showed itself in the reservoir, but did not appear in the new covered standpipe. Mr. Fowler stated that he had no difficulty with the odor and, in answer to another questioner, that no increase in hardness, attributable to filtration, had been noticed.

Prof. Wm. T. Sedgwick, of the Massachusetts Institute of Technology, said that the occasion was a rare one, for the association had just listened to a paper by a man with a long experience with filtration in a northern climate. He then referred to the necessity of protecting surface water supplies from pollution, mentioned the recent epidemics at Maidstone, Kings Lynn and Horsleys, England, all of which were due to surface pollution, and said that it seems as though America is now ahead of England in the conservation of surface supplies.

Mr. John C. Haskell, of Lynn, compared the low cost of central filtration with the high cost of private filters. He thought there could be hardly any city that could not afford to add $3 per 1,000,000 gallons for filtration to the $85 or so which it costs to supply water. He asked Mr. Clark to state the rate of filtration shown as possible by the latest results at the Lawrence Experiment Station. Mr. Clark replied that with careful handling a small plant could filter water as bad as that of the Merrimac River at Lawrence at the rate of 5,000,000 gallons an acre a day, but he would not advise going above 3,000,000 gallons. The latter was a safer rate, besides which it was not economical to run at the higher rate.

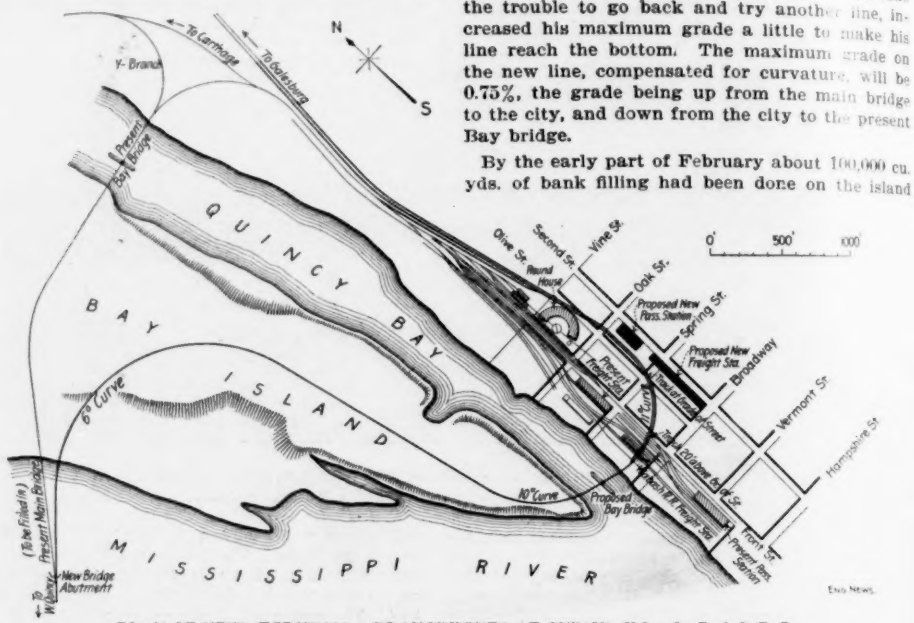
Mr. Fowler said, in conclusion, that an area should be provided for emergency use. He agreed on 3,000,000 gallons as a safe rate. For perfect operation a third bed is needed at Poughkeepsie.

TERMINAL IMPROVEMENTS AT QUINCY, ILL.; CHICAGO, BURLINGTON & QUINCY R. R.

A prominent feature of the improvement works now being carried out by many leading railways in the United States, is the improvement of terminals and yards so as to facilitate train service and yard work and to separate these so as to prevent their interference with one another. A notable instance of this character of improvement is afforded by the changes now being made at Quincy, Ill., by the Chicago, Burlington & Quincy R. R. The accompanying plan will explain the general situation, the heavy lines indicating the new tracks now being built.

The yard lies upon a 1% grade at the north end, and it may be noted that it was here that the officers of the road first experimented with operating freight yards by gravity. All passenger trains run down the center track of the yard, interfering with switching movements and endangering the work of the yard men, the interference and danger being increased by the fact that many of the trains have to "back-up" through the yard. The passenger trains on the St. Louis, Keokuk & Northwestern R. R., which is the most important St. Louis and St. Paul line of the Burlington system (and which has developed a very large passenger business during the past ten years), enter Quincy from the west and leave towards the west. The incoming trains from the west side of the river are turned on the Y-branch east of the present bay bridge and then back down through the yard to the passenger station so as to be in position to pull out again to the bridge "head on," and thus avoid the objections of reversing the train. The Chicago and Kansas City trains come in from the north on the line marked "to Galesburg" and run straight into the passenger station. They are then obliged to back up to the Y-branch, where they were turned before going west over the bridge. This arrangement is an example of the objections to dead-end stations on through lines, which were discussed in our issue of July 16, 1896. Other objections to the present arrangement are that two important streets are crossed at grade, and that the passenger trains run dangerously near to the place where teams are being unloaded at the freight house.

When it was decided to renew the Quincy bridge over the Mississippi (Eng. News, Aug. 26, 1897), it was thought desirable at the same time to introduce some radical improvements in the terminal arrangements, in order to facilitate the prompt movement of all passenger and through freight trains, and to remove the serious obstruction to the prompt handling of all the Chicago and Kansas City trains, and the St. Louis and St. Paul trains. The purpose was to design a general plan to include the Mississippi River bridge, the bridge approach and the new terminals. The plan adopted provides for a complete loop line, both ends of the loop uniting at the bridge, while a spur from the loop connects with the Galesburg main line.



PLAN OF NEW TERMINAL ARRANGEMENTS AT QUINCY, ILL.; C., B. & Q. R. R.

On examination of the Mississippi River bridge it was found that about 1,000 ft. of the east end (including seven spans of the old bridge) could be filled in and still leave ample waterway. The loop commences at the western end of this filled portion, and runs by a 6° curve onto Bay Island, and thence over Quincy Bay to the main land. A 10° curve will lead to the Bay bridge, and an 11° curve from the bridge towards the station. In order to cross the Quincy yard 20 ft. above the grade of the present tracks (as marked on the plan), a very heavy embankment of about 300,000 cu. yds. was required on Bay Island, this bank being about 13 ft. high at the north end and 33 ft. high at the south end. A high bridge, with a draw span, will cross Quincy Bay, and an iron trestle or viaduct will carry the line across the yards, so that there will be no interference with the yard work, and consequently no necessity for slowing down the speed of the trains as at present. In running northward from the new passenger station, the loop line will keep the grade elevation which it has attained between Broadway and Spring St., until it runs into the main line marked "to Galesburg." This will provide for the Chicago and Kansas City trains, and keep the main passenger tracks out of the yard. A passenger train of the St. Louis, Keokuk & Northwestern Ry. entering Quincy from the west will follow the loop line south from the bridge, along Bay Island and over the new Bay bridge to the station. After leaving the station it will proceed northward upon a track parallel with the Quincy and Galesburg track, but dropping in grade until it is low enough to cross the present yard a few hundred feet south of the Y-branch. The train will then proceed down grade to the present Bay bridge and on to the main bridge. It will thus be seen that the train will make a complete circuit and get back upon the main track without being reversed and without getting into the freight yard at all.

Some other advantages have also been gained. The freight station will be nearer to the business portion of the town, and the 1% grade will be removed from the main line from Quincy to Galesburg. This steep grade was run in at the lower end of the grade out of Quincy, and the supposition is that the locating engineer, rather than take the trouble to go back and try another line, increased his maximum grade a little to make his line reach the bottom. The maximum grade on the new line, compensated for curvature, will be 0.75%, the grade being up from the main bridge to the city, and down from the city to the present Bay bridge.

By the early part of February about 100,000 cu. yds. of bank filling had been done on the island and under the east spans of the main bridge, leaving about 250,000 cu. yds. more to be done. The filling in of the main bridge was well under way, and it is not expected that the spring rise in the river will do much damage. The river slopes of the banks will be protected by rip-rap. The filling in of the bridge has thus far been done entirely from below, the old spans being all left in, but the bank will be finished by dumping material from the track. All grading is done by wheel scrapers and by small dump cars hauled by teams on narrow gage tracks, temporary trestles being used for the cars where the bank extends into the water. The contractor for this grading work is Mr. T. J. Shea, of Quincy. The plans for the new passenger and freight stations and the new Bay bridge have not yet been completed, as it is desired to obtain certain privileges from the city before proceeding further with the work. The passenger station will cost about $100,000, and the freight station about $45,000, while $140,000 have already been expended for real estate for the loop.

The 365-ft. draw span of the main bridge over the Mississippi River was strengthened a few years ago, and nine of the sixteen fixed spans are now being renewed with single-intersection through Pratt trusses, including two spans of 250 ft., two of 200 ft., and five of 155 ft. There will also be a plate girder span of 50 ft. They are designed for the standard loads of the C., B. & Q. R. R., and made heavy enough to carry a highway deck which may be put on in the future. Six of the spans are already completed. The material is supplied by the Union Bridge Co., of Athens, Pa., and the erection is done by the railway company, Mr. J. C. Sheahan being Superintendent of Erection. The old masonry was in excellent condition, but to ensure safety under the new and heavier loads the piers were torn down for about 6 ft., and heavy granite copings and bridge seats

were put on. The bridge tracks are about 33 ft. above low water.

The new arrangement of the terminals was designed under the direction of Mr. R. J. McClure, Consulting Engineer, and Mr. E. J. Blake, Chief Engineer of the C. B. & Q. R. R., and we are indebted to Mr. Blake for the plan of the work. Mr. Frank Beckwith is the Resident Engineer.

DEPOSITING CONCRETE UNDER WATER AT CHARLESTOWN BRIDGE, BOSTON, MASS.

The new Charlestown bridge, at Boston, Mass., was built under direction of the Boston Transit Commission, with Messrs. Perkins & White, contractors for the ten masonry piers, and Messrs. A. & P. Roberts, of Philadelphia, contractors for the steel superstructure. In the third annual report of the Commission, the Chief Engineer of the work, Mr. Wm. Jackson, City Engineer of Boston, describes some difficult work in making the foundations for two of the piers of this bridge, where concrete had to be deposited under water.

Except at two of the piers, where hard bottom was found at the depth proposed for the bottom of the concrete, the contractor first dredged to a certain depth and then drove piles as a base for the concrete. The contract required alternate ranges of bearing piles to be cut off at different grades; the 1st, 3d and 5th rows were to be cut off 18 ins. above the bottom of the excavation, and the 2d, 4th, 6th, etc., were to be cut off about 10 ft. below low water; the latter not being cut until a 6-ft. layer of concrete had been deposited on the bottom. The low-level piles were driven first and cut off by a circular saw, and then the high-level piles were driven. Before the latter were cut off a coffer-dam of Wakefield triple-lap sheet-piling was constructed, made up of three layers of 2-in. spruce plank, bolted and nailed together. At the Charlestown abutment 4-in. tongued and grooved spruce plank was used, held in place by a double waling attached to piles driven outside the line of sheeting. At the other piers a frame was built, above water, supported by a curbing attached to certain piles in the outer rows of the foundation, reserved for this purpose. In this frame the vertical members were Wakefield sheet-piling plank, spaced 6 to 10 ft. apart, and connected by three lines of double waling bolted to the verticals at three different heights. When this frame was completed it was lowered to the bottom and enclosed the bearing piles. The posts, or verticals, were then driven, one by one, into the bottom, the frame being sufficiently flexible to permit this. The spaces were then filled by sheet-piling and the frame was bolted to the curbing piles; this curbing afterwards supported the traveler used in laying the concrete. Clay and stone was dumped outside the dam to fill up that part of the excavation made.

These coffer-dams formed a mold for the deposit of the concrete, which latter extended to 5.39 ft. below mean low water, with the top foot in depth of concrete laid after the coffer-dam was pumped out. The concrete was made in proportions of 1, 2 and 5 of English Portland cement, clean, sharp sand and gravel dredged from the harbor. It was mixed in a continuous mixing machine, with an inclined axis, and the issuing concrete was received in barrels and wheeled to the point of deposit.

The method adopted by the contractors for depositing the concrete under water is described as follows: The chute was a tube, 14 ins. diameter at the bottom and 11 ins. at the neck, with a hopper at the top to receive the concrete. This tube was made in removable sections, with outside flanges, to adapt it to different depths, and was suspended by a differential hoist from a truck, moving laterally, mounted on a frame which could travel the length of the pier. In operation, the foot of the chute rested on the bottom and the concrete was dumped into the hopper; the chute was then slowly raised and the concrete allowed to run out in a conical heap, and the loss was made good by dumping in more concrete at the top. As the truck moved on the traveler a ridge of concrete was thus deposited across the pier, the chute being always kept full, or nearly so, by dumping in concrete at the top. When a ridge was finished, the traveler was moved and another ridge was built up as the truck moved back again. When the whole area of the foundation had thus been covered, a similar layer was deposited upon it as soon as the first had sufficiently hardened.

The thickness of each layer of concrete depended upon the height to which the foot of the chute was lifted above the top of the preceding courses. Courses were laid up to 6 ft. in thickness; but it was thought that the best results were secured with 2½-ft. layers. If the bank was made too high, or uneven, or the chute moved or raised too quickly, the charge was "lost," and the water rose inside the chute to the level of that outside. In this case the concrete first dropped in is liable to wash, and a separation of the sand from the cement follows; and as it usually took about one cubic yard of concrete to replace the water in the chute, there is the danger of a deposit of badly-washed concrete whenever the charge is lost. The same thing happens, however, when work is stopped, as the concrete would otherwise set in the chute.

To partially obviate the above difficulty, the contractor was directed to first throw in a quantity of dry cement before dumping in concrete to

Depositing Concrete Under Water Through a Chute at Pier No. 5, Charlestown Bridge, Boston, Mass.

replace the water in a chute; and after any intermission, work was commenced near the center line of the pier, so that any bad concrete would be surrounded by the good. But as the work progressed and the inspector gained experience, accidental losses of the change became infrequent. At two of the piers the concrete was deposited so rapidly that the outward thrust of a considerable depth of unset concrete bulged the coffer-dam, and iron tie-rods had to be put in by divers to keep the coffer-dams from spreading. In these two foundations the chute had to be lifted over these rods, so that there were seven losses of charge per day instead of two. In this emergency a piston was devised, which would be pushed ahead of the concrete and expel the water in the tube; this piston being, of course, lost and imbedded in the concrete at each operation. As the tube was 14 ins. diameter at the bottom and 11 ins. diameter at the neck, the problem was complicated. After several failures, a piston was made of two truncated cones of canvas; one flaring downward to force the water ahead, and the other flaring upward to hold the concrete. The canvas was stiffened and held against the sides of the chute by longitudinal ribs of spring steel wire; the waist was filled by a thick block of wood to which all the springs were attached; and to this block were connected additional steel guides to prevent overturning and a rope to regulate the descent. This piston was a success; very little water forced its way past. But as the cost was considerable, and the evil to be avoided not great enough to justify the outlay, its use was abandoned.

The chute seemed to work best when the concrete was mixed not quite moist enough to be plastic. If mixed too wet the charge was liable to be lost; and if very dry, there was a tendency to choke the chute. An excess of gravel permitted the outside water to force its way in at the bottom; and an excess of sand tended to check the flow of concrete.

As these concrete foundations are to be more or less exposed to the action of sea-water, especially after the sheeting has disappeared, the occasional destruction of Portland cement concrete by sea-water was investigated. Mr. Jackson found, that while there are several opinions and theories as to the cause of such failures and the chemical action involved, the best authorities contend that there is little danger if the concrete is so made as to present a nearly impervious mass, and especially if it is not exposed to unbalanced water pressure to produce a current through the mass. As the Charlestown foundations are wholly submerged, there is no danger of unbalanced water pressure, and unusual care was taken to secure the proper composition of the concrete.

STREAM MEASUREMENTS IN CALIFORNIA BY THE U. S. GEOLOGICAL SURVEY.

By J. B. Lippincott, Los Angeles, Cal.

Beginning in January, 1895, the U. S. Geological Survey resumed measurements on a number of the more important California streams. Previous measurements had been made on some of them for a short time, but owing to a lack of appropriations these observations were discontinued. This work is under the direction of the Hydrographic Branch of the Geological Survey. Mr. F. H. Newell is at the head of this department, and Mr. Arthur P. Davis has the general charge of the stream measurements throughout the United States.

The method usually practiced, with modifications to suit local conditions, is as follows: A gage to show variations on river height to tenths of a foot is placed at the gaging station. Noting the height on the gage the volume of water passing at a given time is determined by soundings and the use of a current meter. Gagings are made from a bridge or cable. These measurements of discharge are repeated for varying heights at intervals as frequent as practicable. The measurements of volume are supplemented on streams with shifting beds by weekly soundings of the river section. A local observer takes the mean daily river heights and makes the soundings when desired. From the measurements of volume and simultaneous rod observations a discharge curve is platted from which daily discharge flow may be obtained by using the daily river heights determined by the local observers. These curves apply until some radical change occurs in the section of the grade of the stream at the gaging station. These results are published in annual bulletins by the Geological Survey and are sold at the cost of publication, 25 cts. each. A brief summary of the results for the year 1896 in California is given in the accompanying table.

On the Stanislaus, several canals divert water from the stream above the gaging station. The au-

Discharge of California Streams for the Year 1896.

Stream and location.	Area of basin, sq. miles.	Discharge, sec.-ft. Maximum.	Discharge, sec.-ft. Minimum.	Discharge, sec.-ft. Mean.	Total for year, acre-ft.	Run off Depth, ins.	Run off Sec.-ft. per sq. mile
Sacramento, at Jelly's Ferry	9,134	130,050	6,000	18,169	13,185,180	27.1	1.98
Stanislaus at Oakdale	1,051	13,050	150	1,935	1,403,462	25.1	1.85
Tuolumne at Lagrange	1,501	11,798	75	2,342	1,743,200	31.2	1.56
San Joaquin at Herndon	1,637	18,800	80	2,755	1,998,547	22.96	1.69
Kings at Red Mountain	1,742	22,100	310	2,582	1,870,905	20.1	1.48
Kern at Bakersfield	2,345	3,611	353	1,122	542,664	3.36	0.35
Tejon at Tejon Ranch House	17	18	3	7	3,491	3.76	0.41
Little Rock at West Palmdale	78	11.5	0.2	9.6	7,882	1.66	0.12
San Gabriel at Azusa	222	222	9	33.5	24,267	2.05	0.15
Sweetwater at Sweetwater Dam	186	...	..	1.39	1,007	0.10	0.01

thority for the record on the Kern River is the Kern County Land Co. On the Tejon Creek the record for July, August and September is missing and a change in stream section prevents the application of the rating curve to December. The record for the San Gabriel includes both the river and canals. The Sweetwater report is for the seasonal year 1895-96, the authority for this being the San Diego Land & Town Co. Mr. H. N. Savage, Chief Engineer.

DESIGNING BUILT-UP WOODEN BEAMS.—III.†

By Edgar Kidwell, M. E.*

Only the keyed or joggled beam will here be considered, as the tests have shown that form to be superior to any other.

Let

P = concentrated load in center of beam, in pounds.
W = total uniformly distributed load, in pounds.
b = breadth of beam, in inches.
d = depth of beam, in inches.
l = span of beam in inches, and L = span in feet.
s = breadth of one key, in inches, Fig. 2.
t = thickness of one key, in inches, Fig. 2.
f = pitches of keys, inches.
N = total number of keys in beam.
T, U, and R, as in Table I.

The summation of the shearing stresses in the neutral plane of a beam carrying a concentrated load in the center is $\frac{3\,P\,l}{4\,d}$, while that in a beam carrying a uniformly distributed load is $\frac{3\,W\,l}{8\,d}$. Using same factor of safety in each case, W = 2 P, hence $\frac{3\,P\,l}{4\,d} = \frac{3\,W\,l}{8\,d}$, therefore, in any beam of given dimensions, the total shearing stress along the neutral plane will be constant, whether the load be uniformly distributed, or concentrated in center, regardless of the length of the beam, if the same factor of safety be used in all cases. But with a center load the unit shearing stresses will be constant all along the neutral plane, as in Fig. 1 (A), while with uniform load they will decrease uniformly from support to center of span, as in Fig. 1 (B).

For working stresses the writer uses the values advised by the "Committee on Strength of Bridge and Trestle Timbers,"† except that for oak keys, which are always made of the best and driest wood obtainable, the compression stress across grain is taken as 800 lbs. per sq. in.

TABLE I.—Safe Working Stresses, Lbs. per Sq. In.

Kind of timber.	Compression. End wood, U.	Compression. Across grn, T.	Shearing. With gr. R.
Factor of safety	5	4	4
White oak	1,400	500*	200
White pine	1,100	200	100
Southern, long-leaf, or Georgia yellow pine	1,600	360	150
Douglass, Oregon and Washington yellow fir	1,600	300	150
Northern or short-leaf yellow pine, hemlock, spruce and Eastern fir	1,200	...	100

* 800 for keys.

Finding the Number of Wooden Keys Needed.

In a beam centrally loaded the keys should evidently be spaced equidistant along the neutral plane, except that none should be put in the center where the bending moment is greatest. It is impracticable to conform the spacing exactly to the theoretical requirements, hence the following scheme is suggested: Determine the number of keys needed to resist the shear; leave in the middle of the beam a length equal to one-quarter of the span free from fastenings of any kind (unless small bolts), then space the keys at equal distances throughout the remaining part of the beam. It is better to use a number of small keys rather than a few large ones, since the beam is less weakened by the key slots and the arrangement approaches more nearly to the conditions existing in a solid beam.

The formulas will assume oak keys, since that is the only material generally available, but they can, of course, be used for any material by substitution of the proper constants.

If keys are to be equally strong against shearing and side pressure, then (Fig. 2)

$$\frac{T \times t}{2} = s\,R, \text{ or } \frac{s}{t} = \frac{T}{2\,R} = \frac{800}{400} = 2,$$

hence the breadth of a key must be equal to twice its thickness. This proportion also prevents turning over in the key slots.

Beam Loaded in Center.

Total shearing stress in neutral plane, to be resisted $= \frac{3\,P\,l}{4\,d}$. But resistance of one key is $\frac{b\,t\,T}{2}$, hence total number of keys for beam is,

$$N = \frac{3\,P\,l}{2\,b\,d\,t\,T} = \frac{18\,P\,L}{800\,b\,d\,t} = \frac{0.0225\,P\,L}{b\,d\,t}.$$

Pitch of Keys.—Length of beam available for keys is $\frac{3}{4} \times l$, hence pitch of keys,

$$f = \frac{3\,l}{4} \times \frac{2\,b\,d\,t\,T}{3\,P\,l} = \frac{b\,d\,t\,T}{2\,P} = \frac{400\,b\,d\,t}{P} \text{ for oak keys.}$$

Example: Find number and spacing of keys for a compound beam made of two sticks of white pine 8 inches wide, 10 inches deep, and 24 feet span. A solid beam 8 inches × 20 inches would carry 5,185 lbs. in center, allowing extreme fiber stress of 700 pounds. If there is room for the keys, the writer usually computes the number from the full theoretical load of solid beam. Assume oak keys in which s = 2 inches, t = 1 inch, then

$$N = \frac{0.0225 \times 5185 \times 24}{8 \times 21 \times 1} = 17.5, \text{ say 18 keys,}$$

$$p = \frac{400 \times 8 \times 20}{5185} = 12.3 \text{ inches,}$$

Uniformly Loaded Beam.

Total shearing stress in neutral plane $= \frac{3\,W\,l}{8\,d}$,

and resistance of one key $= \frac{b\,t\,T}{2}$,

hence $N = \frac{3\,W\,l}{8\,d} \times \frac{2}{b\,t\,T} =$ or, for oak keys,

$$N = \frac{3\,W\,l}{4 \times 800\,b\,d\,t} = \frac{0.01125\,W\,L}{b\,d\,t}.$$

Since the shearing stresses are distributed, as in Fig. 1 (B), we must so space the keys that the perpendiculars from the center of each key will divide up the shaded triangles into parts whose areas are all equal to each other; each key will then do exactly the same duty. This can be done graphically, as in Fig. 3. Lay off A B to represent the half span. Find N from formula, erect at B a perpendicular, lay out B C to any convenient length, greater than A B, such that it will at once scale off into $\frac{N}{2}$ equal parts. With center B and radius B C strike arc C D, intersecting at D a perpendicular from A. Divide D B into $\frac{N}{2}$ equal parts, say at E, O, and F. Drop from these, perpendiculars to line D B, till they intersect at G, H, and K, a semicircle described on D B as a diameter. With center B and radii B G, B H, and B K, strike out points L, M, N; from these drop perpendiculars on A B, and locate Q, R, and S, then will A, Q, R and S be the proper position along the half span for the keys, the point A being at the wall or support.*

Example: Assume same size of beam and keys as in preceding example, but with a uniformly-distributed load. Considering flexure only, allowable load would be 2 × 5185 = 10,370 lbs., hence

$$N = \frac{0.01125 \times 10370 \times 24}{8 \times 20 \times 1} = 17.5, \text{ or say 18 keys,}$$

as before,

Laying out the spacing, and putting the first key at the wall, the pitches of the 9 keys will be approximately, 8½, 9, 9½, 10½, 11½, 13, 15½ and 19½ ins.

Minimum Safe Spacing of Hardwood Keys.

The resistance of beam to shearing between the key slots should be equal to the strength of the keys, hence, Fig. 4, $R\,(f - s) = \frac{t\,T}{2}$, but s = 2 t, hence,

$$f = \frac{\left(\frac{T}{2} + 2\,R\right)t}{R} = \frac{(400 + 2\,R)\,t}{R},$$

which is the minimum safe pitch for the keys. To provide for the extra stress caused by driving up the keys the writer would increase this pitch not less than 25%. If the formula gives a greater pitch than obtained by the preceding rules, the only recourse is to use iron keys.

The experiments showed conclusively that bolts contribute little or nothing in the way of resistance to shearing, apart from the friction caused between the faces of the sticks, and as this friction cannot always be counted upon the writer disregards it and the bolts when computing the keys needed.

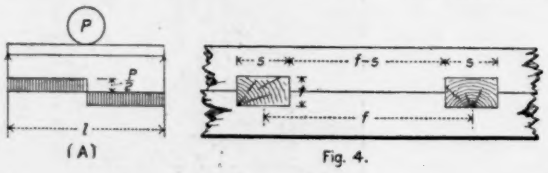


Fig. 4.

Fig. 1. Shaded Portions Represent Vertical Shears.

Fig. 2.

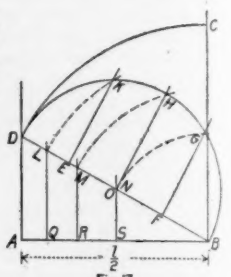


Fig. 3.

TABLE II.—Iron Keys for Beam Loaded in Center.

Material of beam.	No. of keys.*	Pitch of keys.
White oak	$N = \frac{3\,P\,l}{2{,}800\,b\,d\,t}$	$f = \frac{700\,b\,d\,t}{P}$
White pine	$N = \frac{3\,P\,l}{2{,}200\,b\,d\,t}$	$f = \frac{550\,b\,d\,t}{P}$
Sothrn[1] or Ga. yel. pine	$N = \frac{3\,P\,l}{3{,}200\,b\,d\,t}$	$f = \frac{800\,b\,d\,t}{P}$
Northern or short-leaf yellow pine, hemlock, spruce and Eastrn fir	$N = \frac{P\,l}{800\,b\,d\,t}$	$f = \frac{600\,b\,d\,t}{P}$

* Note that l is the span in inches. [1] Southern long-leaf pine.

† The previous articles on this subject were published in Engineering News of March 11, 1897, and Feb. 3, 1898.

*Professor of Mechanical and Electrical Engineering, Michigan College of Mines, Houghton, Mich.

†Association of Railway Superintendents of Bridges and Buildings, Proceedings for 1895, also Engineering News, Oct. 24, 1895.

*It is not worth while to complicate the formula by taking into account the fact that the number of spaces is one less than the number of keys.

*Cf. Angel's Practical Plane Geometry and Projection, p. 46.

Number of Iron Keys Needed.

The pressure allowable in an iron key is dependent only on the crushing strength of the end wood bearing against the key. The preceding formulas, therefore, hold good if we put U, the safe compressive stress on the end wood, in place of T. This gives the results shown in Table II.:

TABLE III.—Iron Keys for Beam with Uniformly Distributed Load.

Material of beam.	No. of keys.*	Pitch of keys.
White oak	$N = \frac{3\,W\,l}{5{,}600\,b\,d\,t}$	Find by graphical method.
White pine	$N = \frac{3\,W\,l}{4{,}400\,b\,d\,t}$	
Southern† or Ga. yellow pine	$N = \frac{3\,W\,l}{6{,}400\,b\,d\,t}$	
Northern or short-leaf yellow pine, hemlock, spruce and Eastern fir	$N = \frac{W\,l}{1{,}600\,b\,d\,t}$	

Minimum Safe Spacing of Iron Keys.

Substituting U in place of T in formula for pitch of wooden keys, we have $(f - s)\ R = \frac{t\,U}{2}$. Assuming as before that $s = 2\,t$, since this proportion gives a key which does not rotate easily in its slot, then

$$(f - 2\,t) = \frac{t\,U}{2}, \quad \text{or} \quad f = \frac{\left(\frac{U}{2} + 2\,R\right)t}{R}$$

which reduces as follows,

For white oak, $f = 5.5\,t$; for white pine, $f = 7.5\,t$, for Southern long-leaf, or Georgia, pine, $f = 7.3\,t$; for hemlock, Northern or short-leaf yellow pine, spruce and Eastern fir, $f = 8\,t$. Similar values can be at once obtained for any proportion of key. They should all be increased about 25% to provide for extra stresses caused by driving up the keys.

In conclusion, the writer would say, in answer to numerous inquiries, that a full report of all work done by him on this subject up to the close of 1897 will be found in the forthcoming volume of "Transactions of the American Institute of Mining Engineers" for 1897, No. XXVII.

NOTES FROM THE ENGINEERING SCHOOLS.

Columbia University.—The school of mechanical engineering has recently received some very valuable gifts. Among them are the equipment for a hydraulic laboratory, consisting of pumps, water meters, tanks, etc., valued at $20,000, presented by Mr. C. C. Worthington in memory of his father, the late H. R. Worthington; a triple expansion marine engine, presented by Mr. W. W. Allis in memory of his father, the late E. P. Allis, of Milwaukee. An air compressor to work up to 250 lbs. pressure is to be attached to this engine, to furnish it with resistance and to enable tests of air compression and transmission to be made. The latest gift to the laboratory is the Vauclain compound passenger locomotive, know as the "Columbia," that was exhibited at the Chicago exhibition in 1893. It was presented to the Baldwin Locomotive Works, and is valued at over $10,000. It will be mounted on friction wheels and supplied with friction brakes so that it can be tested at any speed. The new laboratories will not be in working order until the fall term.

McGill University, Montreal.—A great deal of original work in research is being done in the engineering department, some of it of a most unusual character. Prof. Nicholson has built a machine for subjecting materials to pressures of 250,000 lbs. per sq. in. Under this pressure, when slowly applied, without heating the materials at all, lead, copper and bronze filings have been compacted into solid uniform masses of metal, and made to run out through orifices in the vessel containing them. Peat has been squeezed into a compact mass resembling a brown coal, and small columns of marble, when enclosed in a closely-fitting wrought iron tube, have been made to flow gradually without developing any indications of ordinary crushing. Additional apparatus has been constructed, by means of which further experiments are to be carried out in which the pressure will be applied while the materials are hot and under high steam pressure. Professors Callendar and Nicholson are continuing their researches in the theory of the steam engine, and experiments on cylinder condensation and valve leakage by experiments on the 3,500-HP. engine of the Montreal Street Railway Co.

Purdue University, Lafayette, Ind.—Preparations are being made to install in the Engineering Laboratory a pumping engine formerly used in the water supply system of Lafayette, which has been presented by the city. It is a beam engine of 4,000,000 gallons capacity, built by Clapp & Jones in 1875. It will be used mainly to supply water for the purposes of the Hydraulic Laboratory. A "tumbler" for paving-brick tests is being constructed in the shops. It is a beam engine of the design recommended by the National Association of Paving Brick Manufacturers, except that provision is made for inserting and removing the bricks at the end of the tumbler, thus avoiding the necessity of removing a slat. A temporary impact apparatus for the testing of wire rope under a drop is being constructed; but a permanent apparatus will be placed in the proposed building mentioned below. In this machine provision is made for a record on a revolving drum of the motion of the dropping weight.

Plans and specifications have been adopted for a building, 50×100 ft., to be devoted to the work of mechanical tests of materials. A special room for cement work is provided. The building will contain the equipment now in the main laboratory, with additional apparatus now being provided for.

The experimental work on the new locomotive to be carried out this year includes tests of efficiency under pressures up to 240 lbs. per sq. in., and other tests with high boiler pressures subjected to throttling. A 100-HP. Westinghouse gas engine, with three cylinders set at 90°, is being tested by senior students. The testing work on hand at present includes: Impact tests on wire rope; tests on the strength of nailed joints under transverse loads; tests of the comparative elasticity of steel plates in flexure and tension; a series of tests, now completed, on the various types of brake beams now on the market; tests of full-size steel lateral bracing bridge truss members, with welded ends. The work of testing materials is under the charge of the Associate Professor of Applied Mechanics.

Massachusetts Institute of Technology.—A new building, 58×161 ft., is being erected to accommodate the rapidly-expanding departments of the Institute. The departments of Architecture, Biology, Chemistry, and Mechanical Engineering will all benefit directly by this increased space, and other departments will gain space indirectly. The extension of the Laboratory of Applied Mechanics will include, besides its space in the new building, the basement of the present Architectural Building. The third floor of the Architectural Building, vacated under the new arrangement, will be used by the department of Naval Architecture for lecture, drawing, reading, and model rooms, and will thus relieve the Mechanical Engineering Department by so much space. The fourth and fifth floors of the Architectural Building will provide for the expansion of the Civil Engineering Department. The fourth floor will be used as a drawing-room.

Columbian University, Washington, D. C., is to have a mechanical and electrical engineering laboratory. The engineering departments of this school have been developed in spite of many adverse circumstances. Without any endowment or funds of any sort, the late Professor Fava undertook to teach engineering, gradually accumulating a few surveying instruments and other necessary equipment. Three years ago the departments of mechanical and electrical engineering were established. The latter department has accumulated a number of small dynamos, motors and testing instruments. The former department has secured a fine collection of machine parts illustrating the best modern practice in machine design for the drawing room. The authorities are now installing in the main building an isolated electric lighting plant according to plans by Professors Farwell and Wolff. The plant is to consist of a 25-K-W. generator, direct connected to a two-cylinder gas engine which is being specially designed and constructed by the Westinghouse Machine Co. for this service. The generator is to be provided with both commutator bars and alternating current rings, and may also be run by belt connection from a steam engine. In the latter case the exhaust steam will be used for heating the building.

The department of mechanical engineering is also to have a full complement of testing machines and instruments, so that a regular laboratory course in engineering practice may be given. The attendance in this department has been growing rapidly under the management of Professor Farwell.

WAR TIME BRIDGE BUILDING DRILL is going on at Willets Point, Long Island, at the headquarters of the U. S. Engineer Corps. Recently an 82 ft. span spar-bridge was built by 40 men in three hours. The ravine was supposed to be deep and impassable, by reason of water, and work had to be carried on from one side. The structure was an A-bridge, the four long compression legs being each made of two rough spars lashed together. Two of these legs, with lashed cross pieces at bottom and top, were planted on one bank and the top was inclined towards the other bank by slacking out the guy-lines, and the posts were secured with the top over midstream. A suspended cross floor-beam having been let out with the posts, a temporary footway was laid on this and the abutment beam, and from the center, or from a cantilever lashed to it, men, spars and timbers were passed to the opposite bank. The spars were then lashed together for the other two legs; these were slanted towards midstream by the guys, and when the tops met they were firmly lashed. To make each frame more rigid, two diagonal spars were lashed to the center cross floor-beam and to the center of the two inclined end posts, and another horizontal spar was lashed across the end posts at the intersection with the diagonals. Plank for the floor and guard rails finished the bridge.

THE CHICAGO DRAINAGE CANAL, according to the report of Chief Engineer Randolph, shows 95.4% of the whole work done. During 1897, work to the value of $1,122,072 was executed. The aggregate value of all work done to Jan. 1, 1898, is $20,145,417. The total excavation to that date was 39,428,976 cu. yds.; total retaining wall built, 372,959 cu. yds. The principal work remaining is the tail race at Joliet and the completion of the sections near Willow Springs.

THE MANCHESTER SHIP CANAL report for the half-year ending Dec. 31, 1897, is not pleasant reading for the stockholders. The revenue from the Bridgewater canal alone enables the company to pay its fixed charges; and the profits from this source are greater in proportion than those from the ship canal, as the following figures show:

Ship canal receipts	$536,665
" " expenditures	441,630
" " credit	95,035
Bridgewater canal receipts	110,269

These figures can be better understood when it is realized that the books place the capital expended on the Bridgewater system at $8,921,755, and that on the ship canal, at $66,889,255. The comparative interest is 1.25% on the Bridgewater canal and 0.14% on the ship canal; or, the former earns nine times as much on its capital as the latter. The traffic on the ship canal has grown, however, though less in proportion in 1897 than in preceding years. It is as follows for four years:

	1894.	1895.	1896.	1897.
Sea-going craft, tons.	686,158	1,087,443	1,509,658	1,701,047
In barges, tons	239,501	271,432	316,579	365,336

THE COAL TRADE ON THE GREAT LAKES is treated at length in the late report of Special Agent Mr. George G. Tunnell on the commerce of these lakes. In comparison with rail transportation, lake carriage means cheap coal. During the greater part of the season of 1896, coal was carried from Buffalo to Duluth and Superior, a distance of 997 miles, for 20 cts. per ton. This is due to the fact that coal forms about three-fourths of the west-bound cargo for the vessels bringing ore, grain, flour and lumber East. During 1896 the ports of Lake Erie and Ontario shipped about 9,000,000 tons of coal, and the growth in this trade has been enormous. For example, Buffalo shipped 439,720 tons westward in 1875, and 1,448,086 tons in 1885; in 1895 this port shipped 2,617,268 tons. The shipments from Cleveland, O., rose from 1,433,035 tons, in 1887, to 3,863,645 tons in 1896. This growth in traffic has been accompanied by a wonderful development in the facilities for loading and unloading vessels. As an example of work done by car-dumping machines, a vessel was recently loaded at Cleveland, O., with 5,176 tons of coal in ten and one-half hours, at a total cost of $13, or one-fourth cent per ton of coal.

THE NICARAGUA CANAL COMMISSION is reported as making rapid progress towards completion of its surveys. The survey work on the Pacific divisions is fin-

ished, though the location of the La Flor dam is giving trouble. The borings are said to be unsatisfactory, and it is suggested that two dams may be more advisable; one at La Flor and one just west of the divide on higher ground. The surveys made are to show a cross-sectioned strip of country 2,000 ft. wide over the western division of the canal; instead of the 400 ft. wide strip of the canal company's surveys.

THE DRAINAGE OF TOLLESTON MARSH, in Indiana, has been decided upon by the Supreme Court of that state, and Mr. T. S. Fancher, attorney, of Crown Point, Ind., has been directed to award contracts for the Jarneke ditch, which will drain 7,000 acres of swamp land, the ditch discharging into the grand Calumet river. The marsh has been used as a preserve by a duck shooting club, and several fatal encounters have occurred between the farmers of the neighborhood and the wardens of the club.

THE PIG IRON PRODUCTION of the United States, England and Germany, for 1896 and 1897, is thus tabulated by the "Iron and Coal Trades Review":

	1896, tons.	1897, tons.
United States	8,623,137	9,652,680
United Kingdom	8,563,209	8,789,455
Germany	6,360,982	6,889,067
Totals	23,547,328	25,331,202

THE PRODUCTION OF PIG IRON is again increasing, according to the monthly statistics of the "Iron Age." The following are the figures showing the number of furnaces in blast at the first of each month, and the capacity per week in gross tons during the past year:

	Furnaces.	Weekly c'p'city, tons.		Furnaces.	Weekly c'p'city, tons.
April 1, 1897	153	173,279	Oct. 1, 1897	171	200,128
May 1, 1897	146	170,528	Nov. 1, 1897	183	213,159
June 1, 1897	146	168,380	Dec. 1, 1897	191	226,024
July 1, 1897	145	164,064	Jan. 1, 1898	188	226,608
Aug. 1, 1897	152	165,378	Feb. 1, 1898	184	228,338
Sept. 1, 1897	161	185,506	Mar. 1, 1898	193	234,430

The maximum weekly capacity of the furnaces in blast reached at any date previous to Dec. 1, 1897, was on Nov. 1, 1895, 217,306 tons, when 239 furnaces were in blast. At that time there was a short lived boom in the iron trade which for four months only carried the production above 200,000 tons per week. The present rate of production is about 8% greater than the maximum in 1895, but it is accomplished with nearly 20% fewer furnaces, an important indication of the fact that the large furnaces are driving the small ones out of existence.

THE BESSEMER STEEL PRODUCTION in the United States in 1897, says the "Bulletin" of the Iron and Steel Association, was 5,475,315 gross tons; an increase of 1,555,400 tons, or 39% over 1896. Our highest previous output was 4,909,128 tons in 1895. At the request of steel rail manufacturers, the Association has separated the production of Bessemer steel rails, as follows:

	Under 45 lbs.	45 lbs. and less than 85 lbs.	85 lbs. and over.	Totals.
Pennsylvania, gross tons	51,286	708,475	264,625	1,024,386
Other states, gross tons	33,831	485,296	70,986	590,013
Totals	85,117	1,193,771	335,511	1,614,399

THE COAL STATISTICS of the State of Pennsylvania for 1897 are given in "Mines and Minerals," Scranton, Pa., for March. They have been compiled from data furnished by the State Bureau of Mines and the State Mine Inspectors. The figures are as follows:

	Anthracite. (Long tons.)	Bituminous. (Short tons.)
Tons of coal mined	46,947,354	54,674,452
Tons of coke made	....	a 8,533,291
Persons employed	149,557	88,554
Coal mined per employe	314	617
Coal mined per mine	490	744
Fatal accidents	424	149
Non-fatal accidents	1,106	426
Life lost per 1,000 employes	2.83	1.68
Accidents per 1,000 employes	7.39	4.81
Production per life lost	110,725	366,942
Production per non-fatal accident	42,448	128,344

Compared with the year 1896, these statistics show a decrease in the production of anthracite coal of over 1,000,000 tons, while the output of bituminous has increased nearly 4,500,000 tons, and the output of coke nearly 2,000,000 tons.

THE RAILWAY MILEAGE OF EUROPE, according to recent official reports, was 159,025 miles at the beginning of 1897; or an increase of 3,144 miles over the total for 1896. The countries best supplied with railways, having reference to their areas, are given as follows: Belgium, 3,582; Great Britain and Ireland, 21,217; Germany, 29,355; Switzerland, 2,209; Holland, 1,608; France, 25,089 miles. The mileage of the other countries is as follows: Austria, 18,951; Denmark, 1,695; Spain, 7,615; Greece, 500; Italy, 9,349; Luxembourg, 209; Portugal, 1,451; Roumania, 1,784; Russia proper, 22,455; Finland, 1,484; Servia, 335; Sweden, 6,073; Norway, 1,201; Turkey and Bulgaria, 1,507; Islands of Jersey, Malta and Man, 68 miles. In 1897, Austria-Hungary built 806 miles of new railways; Russia, 555 miles, and Germany 579 miles.

WEATHER TABLE FOR FEBRUARY, 1898. (Furnished to Engineering News by the Department of Agriculture.)

	Stations	Temperature. (Degrees Fahrenheit.) Average.	Max.	Min.	Range.	Wind. Velocity in miles per hour. Average.	Max.	Direction at time of max. velocity.	Precipitation—rain or melted snow—inches. Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	21.6	47	—21	68	8.7	54	NW	3 72	1.12	14
	Portland, Me.	27.6	50	— 4	54	8.0	38	NW	7.61	3.06	9
	New York City	33.0	60	5	55	12.7	48	W	4.06	2.84	14
	Pittsburg, Pa.	32.3	70	0	70	7.2	26	SW	1.60	0.74	10
	Chicago, Ill.	27.6	60	—8	68	19 4	48	NE	2.59	1.05	15
	Omaha, Neb.	29.9	52	—2	54	8.2	27	NW	0.67	0.34	8
	St. Paul, Minn.	20.8	46	—13	59	8.1	29	NW	1.69	0.81	12
	Duluth, Minn.	17.2	38	—18	56	10.6	35	NW	0.89	0.31	9
	Bismarck, N. Dak.	15.8	57	—18	75	10.7	40	NW	0.48	0.15	6
	Average	25.1	53	—9	62	10.4	38		2.59	1.16	11
Southern Cities.	Washington, D. C.	35.0	67	2	65	7.5	46	NW	1.64	0.71	5
	Louisville, Ky.	38.2	71	4	67	9.7	46	W	1.73	0.62	9
	St Louis, Mo.	38.4	71	6	65	11.8	42	SW	1.71	0.77	10
	Savannah, Ga.	51.2	76	23	53	8.5	36	NW	0.56	0.49	4
	Kansas City, Mo.	35 4	65	4	61	9.3	35	NW	1.14	0 81	4
	Jacksonville, Fla.	55.6	76	27	49	7.2	30	SW	2.10	0.92	6
	Chattanooga, Tenn.	41.2	65	12	53	7.5	44	NW	0.68	0.55	2
	New Orleans, La.	56.6	74	36	38	9.0	34	SW	6.20	2 78	7
	Memphis, Tenn.	45 6	67	19	48	11.3	39	NW	1 82	0.73	9
	Palestine, Tex.	54.6	77	23	54	7.1	26	S	4.68	3.74	6
	Average	45.2	71	16	55	8.9	38		2.23	1.19	7
Western Cities.	Helena, Mont.	34.2	55	—1	56	9.2	50	SW	0 52	0.34	8
	Port Angeles, Wash.	42.1	57	30	27	5.4	38	W	3.62	0.60	14
	San Francisco, Cal.	52 6	70	43	27	8.3	36	NE	2.13	0.78	11
	Salt Lake City, Utah.	35.6	60	16	44	5.1	26	NW	0 38	0.29	3
	Santa Fe, N. Mex.	36 7	58	16	42	5.3	26	N	0 30	0.27	2
	Denver, Colo.	37 8	65	10	55	7.6	53	W	0 68	0 61	4
	Yuma, Ariz	62 0	84	40	44	——	30	N	0.00	0.00	0
	Average	43.0	64	22	42	6.8	37		1.09	0.41	6

A CHICAGO-NEW YORK RAILWAY line in the interests of the Lake Erie & Western R. R. is to be effected by the construction of a few connecting links, and will be in operation during the present year. From Kankakee, on the Illinois Central R. R., the Findlay, Fort Wayne & Western R. R. will build 140 miles to its line at Fort Wayne, Ind., and 12 miles from Findlay to Carey, O., connecting at Carey with the Northern Ohio R. R., which extends to Akron. From Akron, the Cleveland & New Castle R. R. will build a line 70 miles long to New Castle, Pa., where it will connect with an extension of 98 miles, which the Buffalo, Rochester & Pittsburg R. R. will build westward from Punxsatawney. This will give a new and direct outlet to the west for the coal fields and coke works of the B. R. & P. Ry., and for the great industrial districts around New Castle, Youngstown, Niles, etc. From Kankakee to New Castle the line will be owned by the Lake Erie & Western R. R. interests. A through freight route to New York will be maintained over the B. R. & P. R. R., the Beed Creek R. R., Philadelphia & Reading R. R. and Central R. R. of New Jersey, while the Illinois Central R. R. will afford access to Chicago. A through passenger route may also be maintained, but this is a secondary consideration. Mr. G. L. Bradbury, vice-president and general manager of the Lake Erie & Western R. R., informs us that the Cleveland & New Castle line will be built this year, and will involve some heavy work, but that the heaviest work will be on the extension of the Buffalo, Rochester & Pittsburg R. R.

A LAKE AND RAIL ROUTE between Chicago and eastern points is to be established by the Canada Atlantic Ry., whose new line to Parry Sound has been completed, and which is interested in the new direct line from Otttawa to New York. Traffic arrangements have also been made with the Intercolonial Ry. for through service to Halifax. The company has purchased five modern steel steamers which will run from Chicago, Milwaukee and Duluth to Parry Sound, on Georgian Bay.

COMPETITIVE DESIGNS FOR SWEDISH RAILWAY station, at Stockholm, are invited by the Royal Administration of the Swedish State Railways. The designs include arrangement of new railway stations, junctions, etc., within the city. The first prize is $3,230; second, $2,150, and third, $1,075; and the time for competition expires at noon on Aug. 31, 1898. Full particulars as to the nature of the work will be furnished by the Swedish-Notwegian Legation, 2011 Q. St., Washington, D. C., or by Mr. August Peterson, the Vice-Consul of Sweden and Norway, Le Droit Building, corner F and Eighth Sts., Washington, D. C. For the use of the drawings in this competition, security to the amount of $13.50 will be required, but this sum will be refunded when the drawings are returned.

BROOKLYN ELEVATED RAILWAY CARS will begin running over the East River Bridge on June 1, according to present prospects. Under the new arrangement about the same number of cars will run over the bridge as at present, but about one-half only will be the regular bridge cars. The effect of the new system upon the bridge receipts has yet to be tested. Each trolley car crossing the bridge pays 5 cts. toll, and each Brooklyn Elevated car will pay the city 12½ cts. The trolley cars commenced crossing on Feb. 16, 1898. The comparative figures for bridge passengers and receipts appear as follows in the bridge reports:

		Passengers.	Receipts.
January,	1897	3,786,259	$95,541.09
"	1898	4,148,011	104,004.24
February,	1897	3,470,905	87,563.66
"	1898	3,075,[illegible]	77,564.94

As the trolley was only in operation for 13 days of the last month reported the drop in traffic is marked. Superintendent C. C. Martin says that the daily bridge receipts now show an average decrease of $1,700, when compared with those of last year.

STEEL AND WOODEN FREIGHT CARS are compared in respect to first cost, cost of maintenance, durability and weight in some figures recently made public by Mr. Charles S. Schoen, of the Schoen Pressed Steel Co. Mr. Schoen compares a 30-ton wooden car and a 50-ton steel car, including interest and cost of maintenance for the life of each car. The cost of repairs is averaged at $40 per year for the wooden car, and at $20 per year for the steel car throughout a life of 15 and 30 years, respectively. He takes the first cost of the wooden car at $525, to which he adds interest and cost of repairs for 30 years. He sums up a cost of $106.50 during the life of the wooden car, or $5.55 per year per ton carrying capacity. Then he takes a modern steel car at a first cost of $810, allows the same rate of interest, and provides for repairs. From this he figures a cost of $95.60 per year during the life of the steel car, or $1.91 cost per year per ton carrying capacity. He estimates the difference in the cost per year per ton carrying capacity in favor of steel cars at $1.64, which is equal to 46.2%.

Another advantage claimed for the steel car is the saving of dead weight. The estimate made by Mr. Schoen assumes that train loads of 1,500 tons of paying freight are hauled, and that the wooden car weighs 16½ tons and the steel car 17 tons. To haul 1,500 tons, 50 wooden cars are required, weighing 825 tons. To haul the same amount of freight 30 steel cars are required weighing 510 tons. Thus the dead weight saved for train load in favor of steel cars is 315 tons. If 500 steel cars are used it will give 16⅔ full trainloads, which multiplied by 315 (tons of dead weight saved per train), gives 5,250 tons of paying freight gained for each run of the 500 steel cars.

A NEW BRIDGE OVER THE THAMES, in London, has been approved, as to design, by the London County Council. It would be located at Vauxhall and built of granite backed by concrete. The bridge would have five arches, with a central span of 149 ft. 9 ins., two spans of 144 ft. 6¾ ins. and two land spans of 130 ft. 6¾ ins. The entire structure would be 760 ft. long, and only 28 ft. high above high water mark. The width is not stated, but the estimated cost is $1,900,000.